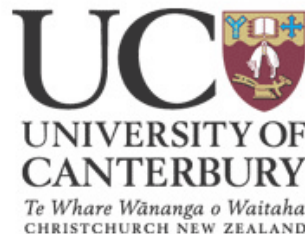


# **Assessing and improving the effectiveness of staff training and warning system response at Whakapapa and Turoa ski areas, Mt. Ruapehu.**

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A thesis  
submitted in partial fulfilment  
of the requirements for the Degree  
of  
**Master of Science in Hazard Management**  
at the  
**University of Canterbury**  
by  
**Amy Nadine Christianson**

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**UNIVERSITY OF CANTERBURY**

**2006**



## **Frontispiece**



**Mt. Ngauruhoe at sunrise from Whakapapa Village**



## Abstract

Ruapehu is an active volcano located on the North Island of New Zealand, with the most recent major eruptions occurring in 1945, 1969, 1975, and 1995/96. Ruapehu is also home to the three major North Island ski areas, Whakapapa, Turoa, and Tukino. Because of the high frequency of eruptions, there is a significant volcanic hazard at the ski areas particularly from lahars which can form even after minor eruptions. Most recently, lahars have affected Whakapapa ski area in 1969, 1975, and 1995/96. The most significant risk at Turoa is from ballistic bombs due to the proximity of the top two T-Bars to the crater. Ash fall has also caused disruption at the ski areas, covering the snow and causing damage to structures. There is yet to be a death at the ski areas from a volcanic event; however the risk at the ski areas is too high to be completely ignored.

The ski areas at Whakapapa and Turoa are currently operated by Ruapehu Alpine Lifts (RAL), who have been significantly improving their commitment to providing volcanic hazard training for their staff and preparing for handling a volcanic eruption. RAL is joined by the Institute of Geological Sciences (GNS) and the Department of Conservation (DoC) in trying to mitigate this risk through a range of initiatives, including an automated Eruption Detection System (EDS), linked to sirens and loudspeakers on Whakapapa ski areas, as well as by providing staff training and public education.

The aim of this study was to provide RAL with recommendations to improve their staff training and warning system response. Staff induction week at both Turoa and Whakapapa ski areas was observed. Surveys were distributed and collected from staff at both ski areas, and interviews were conducted with staff at Whakapapa ski area. Data obtained from staff interviews and surveys provided the author with insight into staff's mental models regarding a volcanic event response. A simulation of the warning system was observed, as well as a blind test, to collect data on the effectiveness of training on staff response.

Results indicated permanent and seasonal staff were knowledgeable of the volcanic hazards that may affect the ski areas, but had differing perspectives on the risk associated with those hazards. They were found to be confident in the initial response to a volcanic event (i.e. move to higher ground), but were unsure of what would happen after this initial response. RAL was also found to have greatly improved their volcanic hazard training in the past year, however further recommendations were suggested to increase training effectiveness. A training needs analysis was done for different departments at the ski areas by taking a new approach of anticipating demands staff may encounter during a volcanic event and complementing these demands with existing staff competencies. Additional recommendations were made to assist RAL in developing an effective plan to use when responding to volcanic events, as well as other changes that could be made to improve the likelihood of customer safety at the ski areas during an eruption.

**Key words:** Ruapehu, skiing, volcanic hazards, lahars, management, risk perception, eruption response plan, evacuation, training needs analysis, mental models



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# Chapter One

## Introduction

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### 1. INTRODUCTION

#### 1.1 General Introduction

Ruapehu is an active andesitic cone volcano, situated at the south end of the Taupo Volcanic Zone, North Island, New Zealand (Wilson et al., 1995), and represents a significant volcanic hazard due to the regular use of areas on and surrounding the volcano by tens of thousands of people. Most recent eruptions occurred in 1969, 1975, 1995, and 1996. Ruapehu contains a crater lake, which modifies eruptive behaviour with the chance of dangerous mudflows and lahars forming after even minor eruptions (Wilson et al., 1995). An eruption in 1945 at Ruapehu was the largest in New Zealand in the century (Neall et al., 1995), and more than 60 lahars (volcanic mudflows) have occurred on Ruapehu since 1860 (Geonet, 2002).

Whakapapa and Turoa ski areas are situated on the upper slopes of Ruapehu and in excess of 20,000 skiers use these two areas on some days. Chairlifts and tows carry skiers within two kilometres of the summit crater, and during the 1995 eruption lahars entered the Whakapapa ski area 90 seconds after the initial eruption (Nairn et al., 1996). No one was injured as the ski area was closed but extensive damage was done to all three ski areas on Ruapehu (Johnston et al., 2000). A range of volcanic hazards still pose significant risk to skiers in both areas, such as a potential hydrovolcanic eruption or the possible formation of a lahar (Neall et al., 1995).

The Institute of Geological and Nuclear Sciences (GNS), the ski resort company (Ruapehu Alpine Lifts, RAL), and the Department of Conservation (DoC) have developed a range of initiatives to mitigate this risk, such as an automated electronic Eruption Detection System (EDS), telemetered lahar warning system including sirens and loud-speaker message, staff training, and public education. The EDS uses seismometers to measure volcanic tremor and air pressure sensors to detect sound waves given off by material ejected from the crater (Geonet, 2002). This project has been ongoing for the last 5 years at Whakapapa ski area and was expanded to Turoa in 2004.

The issue of managing the eruption response at Whakapapa and Turoa ski areas is very complex for several reasons. One is that eruptions on Ruapehu occur frequently and sometimes without warning. Another is that whether the eruption will actually affect the ski areas depends on many factors, such as the type of eruption and wind direction. Also, the majority of people on the mountain are visitors with differing levels of knowledge about the risk and how to respond to it. Most hazard preparedness research focuses on residents of a particular community, which made finding relevant literature for this study difficult. The transient nature of those at risk places even greater demands on staff at the ski areas to inform visitors and to guide their response in the event of a volcanic crisis. Adding complexity to the issue is that the ski area is already a high risk workplace, with many other hazards for staff to worry about every day (i.e. avalanches and blizzards). Also, the nature of the response demands fall outside the normal job demands of most staff. The stress associated with this adds to the challenge, and highlights a need for training.

Therefore, it is imperative that lahar risk management planning involves complementing existing staff competencies with those required to facilitate effective response and recovery following a volcanic crisis. This has called for a new approach to training needs analysis that occurs by anticipating the demands that staff may encounter (Paton and Flin, 1999). In order to identify gaps between routine competencies and those required to deal with a volcanic crisis, the current research project at Whakapapa and Turoa ski areas involved observing staff training at both areas, analyzing survey results from seasonal staff and conducting semi-structured interviews with both permanent and seasonal staff at Whakapapa ski area, as well as observing two tests of the warning system.

## 1.2 Objectives

The following objectives were developed at the beginning of this research project:

*Objective 1:* To examine staff understanding of the risks of volcanic hazards affecting the ski areas.

*Objective 2:* To examine staff knowledge of procedures for the response to a volcanic event, particularly the evacuation stage (Stage 2).

*Objective 3:* A practical system consisting of effective training session and simulations can be designed to mitigate the risk.

*Objective 4:* A realistic volcanic hazard response plan can be developed for the ski area using a CIMS structure.

To meet these objectives, the research strategy was as follows:

- Review international literature on staff training, effective response to warning systems, simulation exercises, human response to emergencies, and hazard mitigation,
- Determine staff knowledge of the volcanic hazards, warning system, and training,
- Observe a simulation of the warning system, and
- Observe staff reactions in a 'blind' test of the warning system to determine training knowledge retention.
- Use interviews and surveys to determine staff knowledge of ski area evacuation procedures during a volcanic event
- Determine the existence and effectiveness of an eruption response plan,
- Evaluate the effectiveness of current staff training from outputs of above objectives and critical analysis using human psychology theories,
- Evaluate staff training needs for Whakapapa and Turoa ski areas, and
- Provide recommendations on how to improve lahar hazard training at Whakapapa and Turoa ski areas to maximize effective response to the warning system.

Several methods were used to fulfil these objectives and are detailed in Chapter 5 of this thesis. They include:

- Literature review
- Observation of ski area staff training
- Surveys of ski area staff
- Interviews with ski area staff
- Observation of a simulation exercise
- Observation of a blind test of the warning system

Grounded theory methodology was used to build theory from the data that was collected.

### **1.3 Outline of Thesis**

#### **1. Introduction**

This chapter provides a brief synopsis of the issues RAL faces on Ruapehu in regards to volcanic hazards, as well as measures which are being taken to mitigate the risk. It also covers the hypotheses and objectives of the research and a brief summary of the methodology.

#### **2. Background Information on Ruapehu**

Chapter 2 briefly summarizes the geology of Ruapehu, and the recent eruptive history. The Crater Lake tephra barrier failure issue is also discussed.

#### **3. Background Information on Skiing at Ruapehu**

This chapter summarizes the history of skiing on Ruapehu, the formation of the company Ruapehu Alpine Lifts (RAL), and the constraints under which it operates. Potential volcanic hazards and the impacts of past events on the ski area discussed, and the Eruption Detection System (EDS) is introduced.

#### **4. Past research on staff training at the ski areas and Eruption Response Plans**

This chapter summarizes past research at Whakapapa ski area, and the volcanic hazard public education campaign. CIMS is introduced, as well as the eruption response plans of both DoC and RAL.

#### **5. Methodology**

In this chapter, the methodology of this research project is detailed and discussed. The Grounded Theory Method is then introduced and explained, including the selection of themes, and the reliability and validity of the data.

#### **6. Results and Initial Discussion**

Results from the research study are presented here, including staff training observation, survey data, interview data, and warning system test observations.

#### **7. Further Discussion and Recommendations**

The implications of the results are further discussed in this chapter, and recommendations are made to the ski areas to improve staff training and response effectiveness.

#### **8. Conclusion**

In the final chapter, the main results and conclusions from the research project are summarized



## Chapter Two

# Background Information on Ruapehu

---

This chapter briefly summarizes the geology of Ruapehu and the recent eruptive history. Covered in detail are the risk to life of an eruption at Ruapehu, past disasters during a volcanic eruption including the Tangiwai disaster, the possibility of renewed volcanism and types of events that may occur, and hazard zones on Ruapehu in regards to differing frequency events. The Crater Lake tephra barrier failure is also discussed, with emphasis on the lack of likelihood of such an event affecting the ski area.

## 2. BACKGROUND INFORMATION ON RUAPEHU

### 2.1 Geology of Ruapehu

Ruapehu is an active, andesitic stratovolcano located on the North Island of New Zealand at the south end of the Taupo Volcanic Zone. It lies in Tongariro National Park (Figure 2.1) south of Ngauruhoe and Tongariro. Ngauruhoe is the youngest ( $<2.5$  ka) and most active cone vent of Tongariro, last erupting in 1975 (Wilson et al., 1995). Volcanism in this area is due to rapid extension and the oblique subduction of the Pacific Plate beneath the Australian plate, specifically along the Hikurangi margin (Hurst and McGinty, 1999). It is believed that Ruapehu has been in existence for 0.5 million years, however the oldest dated lavas are 230,000 years old. It has been built up and partly destroyed occasionally during its existence by both sector collapse and glacial erosion, with glacial erosion occurring to the present day (Wilson et al., 1995). It is the highest mountain on the North Island of New Zealand at its current height of 2797 metres. Present-day



Ruapehu was created in four cone-building episodes. Holocene eruptions occurred along a 25 kilometre long lineament, which extends from the modern vent northeast to the Tongariro volcano (Figure 2.2).



Figure 2.1 Location of Tongariro National Park

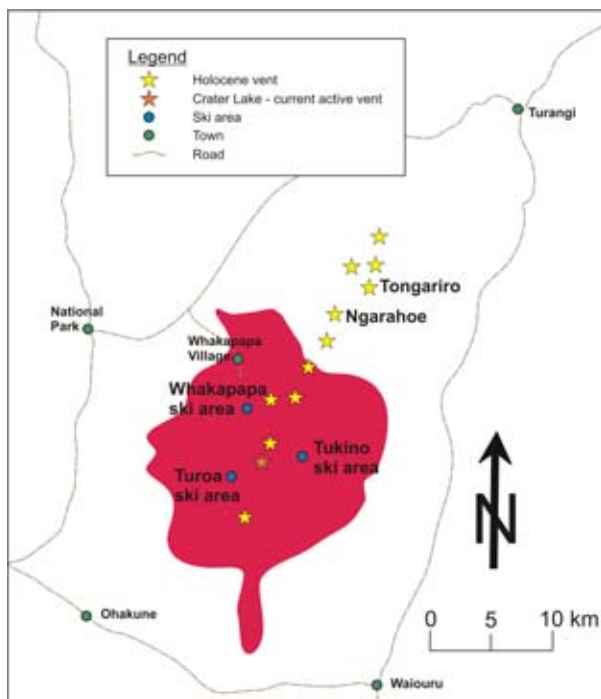


Figure 2.2 Holocene eruption vents at Ruapehu (modified from Houghton et al., 1987)

These eruptions have taken place from two summit and four flank vents. There is little evidence on Ruapehu of past volcanism, due to the rapid erosion of the rock record from the steep flanks of the volcano (Hackett and Houghton, 1989), as well as cone collapse and glacial erosion (Wilson et al., 1995). A more complete record is found in the ring plain surrounding Ruapehu. Stratigraphy here implies that in the late Pleistocene-Holocene (post 22,600 years B.P.) volcanic events at Ruapehu were dominated by small volume tephra eruptions and lahars, while debris avalanches and pyroclastic flows were rare (Donoghue et al., 1999). Activity at Ruapehu has included Strombolian explosive eruptions, eruptions of aa lava, eruptions of block lava areas, one (possibly two) sub-plinian eruptions, a debris avalanche caused by minor cone collapse on the north-western flank of the volcano, and creation of two large lahars (dated at approximately 407 and 756 years B.P.) which extended up to 160 kilometres from the volcano (Houghton et al., 1987).

## 2.2 Recent Eruptive History of Ruapehu

### 2.2.1 Risk to Life

In terms of probability, a volcanic event at Ruapehu (particularly the formation of Whakapapa lahars) poses the greatest risk to human life than any other volcano in New Zealand (Houghton et al., 1987). Neall et al. (1995) suggest four reasons why Ruapehu is such a threat.

1. Ruapehu is an active volcano, periodically erupting with both major and minor events. Major events have included the formation of substantial lahars that would certainly have caused loss of lives if they had occurred during the day.
2. The presence of a crater lake makes Ruapehu more dangerous. The Crater Lake, at 2,540 metres elevation, contains 7 million m<sup>3</sup> of acidic water which can rush down surrounding valleys. This lake has the potential to turn even minor eruptions into dangerous events due to the formation of lahars, which sweep down drainage outlets on the mountain (Wilson et al., 1995). In fact, Ruapehu is the only volcano known to produce lahars by depositing water from a crater lake onto surrounding snow/ice (Otway et al., 1995).
3. Ruapehu has a volcanic activity history extending back 240,000 years, making it likely that the volcano will keep erupting periodically in the future as it has done in the past.
4. Ruapehu has become a major tourist destination, especially for skiing at Whakapapa, Turoa, and Tukino ski resorts, and is located close to several major highways, railways, air, and electricity routes. An eruption would likely cause disruption to these services.

Both phreatomagmatic and magmatic eruptions have occurred at Ruapehu in the historical record. Phreatomagmatic eruptions have been the most common, occurring when andesitic magma is injected into the Crater Lake. The difference in heat between the hot magmatic gases, hot rock and fragmenting magma, and the colder water generate violent steam explosions which eject water out of the lake and into the crater basin and surrounding areas (Otway et al., 1995). When these deposits fall outside of the crater basin at Ruapehu, they continue down-slope, incorporating snow, ice, and sediments to become a lahar (Houghton et al., 1987). The most recent eruptions at Ruapehu in 1995/96 were sustained phreatomagmatic/magmatic eruptions, with a total duration of 20 weeks (Johnston et al., 2000). Magmatic events have also occurred at Ruapehu, however only two magmatic events have occurred during historical record keeping, in 1861 and 1945. The eruptive sequence during these magmatic events consisted of dome building (from magma extrusion) and explosive eruptions. The principal hazard during these events is ash fall, which is spread over a large area (Houghton et al., 1987). The total duration of the 1945 magmatic eruption at Ruapehu was 40 weeks (Johnston et al., 2000).

Ruapehu eruptions are very unpredictable as to the time of day and season an eruption will occur in, as well as whether the volcano will produce warning signs before a major event (Table 2.1). By looking at the four main historical eruptions at Ruapehu documented by Otway et al. (1995), it is clear to see that no pattern emerges as to the time of day or the season the main event occurs in. In 1969, the main event occurred just after midnight, whereas in 1995, the main event occurred around 5pm in the afternoon. The 4 eruptions have also occurred in each of the 4 different seasons, with 1945 beginning in the summer, 1969 beginning in the winter, 1975 beginning in the fall, and 1995 beginning in the late winter/early spring. Warning signs preceded the main 1995 eruption for several months, however the magnitude of the eruption on September 23<sup>rd</sup> was unexpected. It is relatively unknown whether warning signs preceded the 1945, 1969, and 1975 eruptions, however both the 1969 and 1975 eruptions were preceded by earthquakes up to half an hour before the main event. It is generally thought that Ruapehu eruptions occur in bad weather (Department of Conservation, 1996) as was the case with the 1975 eruption, where the initial event was not observed due to bad weather. However, the major eruptions of 1945, 1969, and 1995 were all observed, with the 1995 eruption occurring in the late afternoon of a fine day.

<b>Event</b>	<b>Style of Eruption</b>	<b>Time of Day of Major Beginning Event</b>	<b>Beginning of event - Date/season</b>	<b>Warning Signs of impending event</b>
<b>1945</b>	Magmatic	Unknown	Thursday, March 8/ Summer	Dome growth
<b>1969</b>	Phreatomagmatic	Night (0033h)	Sunday, June 22/ Winter	Earthquakes beginning at 0004h.
<b>1975</b>	Phreatomagmatic	Early morning (0359h)	Thursday, April 24/ Fall	Increase in seismic activity at 0350h.
<b>1995/96</b>	Phreatomagmatic	Late afternoon (1700h)	Saturday, September 23/ Early Spring	Seismic swarms, fluctuations in Crater Lake temperature and chemistry for several months before main eruption.

Table 2.1 Time of day and season of main historical Ruapehu eruptions  
(compiled from Otway, 1995)

### *2.2.2 Disasters at Ruapehu*

Lahars or other dangerous volcanic hazards may occur without an eruption on Ruapehu. The most famous example is the December 24<sup>th</sup>, 1953 Tangiwai disaster. Healy (1954) described how the lahar was created when a temporary ash/ice barrier formed by the 1945 eruption at the Crater Lake collapsed, spilling water into the Whangaehu drainage basin. This lahar swept down the valley, destroying the Tangiwai railway bridge, subsequently derailing the Wellington-Auckland express train and causing the loss of 151 lives (Houghton et al., 1987). Another event occurred on April 26<sup>th</sup>, 1968, when it is believed intrusion of lava caused spillover of the Crater Lake, forming a lahar which flowed down the Whangaehu valley (Houghton et al., 1987). A simple solution to prevent these events would be to drain the Crater Lake or construct alternate lahar passage-ways, which have been proposed by numerous authors (Houghton et al., 1987; Otway et al., 1995; Department of Conservation, 1996). However, it has been decided that engineering mitigation is not possible. See Section 2.4 for a more detailed discussion.

Ruapehu has been very active in historical times. Major eruptions include 1861, 1889, 1895, 1903, 1907, 1925, 1945-1946, 1966, 1968, 1969, 1971, 1975, 1977, 1988, and 1995-1996 (Otway et al., 1995). Smaller eruptions occurred in 1978, 1979, 1980, 1981-1982, 1985, and 1987. All of these events have occurred at the western summit crater, which has been occupied by the Crater Lake (0.16 km<sup>2</sup>). Major lahars, either destructive or having the potential to be destructive, were formed during the eruptions in 1969, 1971, 1975, and 1977 eruptions (Houghton et al., 1987), and more recently the 1995 eruption of Ruapehu. The frequency of lahar producing events stresses the importance for the ski areas to be prepared to handle a volcanic crisis, as they can occur often and with little warning and have the potential to cause disasters. The ski areas must also be flexible in how they plan to respond, as each volcanic event is unique. See Table 2.2 for a complete description of historical eruptions at Ruapehu.

Table 2.2 A complete description of historical eruptions at Ruapehu (compiled from Otway, 1995; Dept. of Conservation, 1996; Nairn, 1996)

Date	Event	Lahar generated	Catchments affected	Estimated total volume (m <sup>3</sup> )	Lahar notes	Hazards Associated	Ski areas affected?
13-Feb-1861	likely non-eruption related lahar	<input checked="" type="checkbox"/>	Whangaehu	6 000 000	Likely the largest historical Ruapehu lahar		
16-May-1861	phreatomagmatic eruption	<input checked="" type="checkbox"/>					
1-May-1889	Phreatomagmatic eruption	<input checked="" type="checkbox"/>	Whangaehu	100 000	River rose ~1m in a few minutes		
10-Mar-1895	phreatomagmatic eruption	<input checked="" type="checkbox"/>	Whangaehu	2 000 000	Observed		
			Whakapapanui/ Whakapapaiti		Likely but no supporting evidence		
			Mangaturuturu		Likely but no supporting evidence		
1903	Phreatomagmatic eruption	<input checked="" type="checkbox"/>	Whangaehu	100 000	Observed	Eruption cloud directed over Whakapapa area	
			Whakapapanui/ Whakapapaiti		Possible, none observed		
15-Apr-07	phreatomagmatic eruption	<input checked="" type="checkbox"/>				Ash and mud covered mountain, large rock/snow slip on Turoa side	
22-Jan-25	No eruption seen	<input checked="" type="checkbox"/>	Whangaehu	100 000	River rose 3m, eroded bridge piles		
3-Feb-25	phreatomagmatic eruption	<input checked="" type="checkbox"/>	Whangaehu	100 000	similar magnitude to Jan 1925 lahar		
March 1945 to December 1946	Combination of phreatomagmatic and magmatic eruptions	<input checked="" type="checkbox"/>				Ash fall	<input checked="" type="checkbox"/>
24-Dec-53	likely non-eruption related lahar	<input checked="" type="checkbox"/>	Whangaehu	1 650 000	Lahar washed out Whangaehu rail bridge, led to Tangiwai Rail Disaster		
24-Jul-66	phreatomagmatic eruption	<input checked="" type="checkbox"/>	Whangaehu	1 000	Small lahar		
26-Apr-68	Magmatic event	<input checked="" type="checkbox"/>	Whangaehu	700 000	Long duration, long peak lahar (total volume)		
22-Jun-69	phreatomagmatic eruption	<input checked="" type="checkbox"/>	Whangaehu	67 000	Estimated velocity of 17m/s at 1 kilometre from Crater Lake. Destroyed Dome Shelter and Staircase Kiosk on ski area.	Ash fall, acid water	<input checked="" type="checkbox"/>
			Whakapapanui/ Whakapapaiti	117 000			
			Mangaturuturu	24 000			

8-May-71	phreatomagmatic eruption	<input checked="" type="checkbox"/>	Whangaehu	41 000			
16-May-71	phreatomagmatic eruption	<input checked="" type="checkbox"/>	Whangaehu	72 000			
16-May-71	phreatomagmatic eruption	<input checked="" type="checkbox"/>	Whangaehu	58 000			
19-May-71	phreatomagmatic eruption	<input checked="" type="checkbox"/>	Whangaehu	18 000			
21-May-71	phreatomagmatic eruption	<input checked="" type="checkbox"/>	Whangaehu	9 000			
3-Jul-71	phreatomagmatic eruption	<input checked="" type="checkbox"/>	Whangaehu	5 000			
4-Jul-71	phreatomagmatic eruption	<input checked="" type="checkbox"/>	Whangaehu	19 000			
24-Apr-75	phreatomagmatic eruption	<input checked="" type="checkbox"/>	Whangaehu Whakapapanui/ Whakapapaiti Mangaturuturu	1 800 000 900 000 600 000	The lahars damaged three facilities on the Whakapapa ski area, bridges, and hydroelectric power schemes	Hot ballistics 1.6 km from vent, ash fall extended 115 km SE	<input checked="" type="checkbox"/>
27-Apr-75	phreatomagmatic eruption	<input checked="" type="checkbox"/>	Whangaehu		Small lahar		
2-Nov-77	phreatomagmatic eruption	<input checked="" type="checkbox"/>	Whangaehu Mangatoetoenui	130 000		Water, ash, blocks, and bombs ejected	
8-Dec-88	phreatic eruption	<input checked="" type="checkbox"/>	Whangaehu	13 200	Small lahar	Water, rock, and ash ejected to north and northeast of vent	
18-Sep-95	phreatomagmatic eruption	<input checked="" type="checkbox"/>	Whangaehu		Estimated velocity of 15 m/s		
23-Sep-95	phreatomagmatic eruption	<input checked="" type="checkbox"/>	Whangaehu Whakapapaiti Mangaturuturu		Largest lahar down Whangaehu valley of 1995 eruptions  Two separate lahars produced. One passed within metres of the Far West T-Bar at Whakapapa	Ash fallout to east, large blocks thrown 1 kilometre from crater	<input checked="" type="checkbox"/>
26-Sep-95	phreatomagmatic eruption	<input checked="" type="checkbox"/>				Ash fall	<input checked="" type="checkbox"/>
Oct-95	phreatomagmatic eruption	<input checked="" type="checkbox"/>	Whangaehu		Numerous lahars generated during October	Ash fall	<input checked="" type="checkbox"/>
Late October-1995	Secondary	<input checked="" type="checkbox"/>	Mangatoetoenui		Destroyed walking track bridge	Secondary debris flow ran down Whakapapa ski area	<input checked="" type="checkbox"/>
17-Jun-96	phreatomagmatic eruption	<input checked="" type="checkbox"/>	Whangaehu		Small lahar	Ash fall	<input checked="" type="checkbox"/>

### 2.2.3 *Renewed Volcanism*

Prior to the 1995/1996 eruptions at Ruapehu, it was proposed by Houghton et al. (1987) that renewed volcanism at Ruapehu will likely occur in six possible ways:

- 1) phreatomagmatic eruption through Crater Lake (which occurred during the 1995/96 eruption),
- 2) construction and explosion of lava domes on the western summit vent,
- 3) Strombolian or sub-Plinian eruption somewhere along the Holocene vent lineament,
- 4) extrusion of lava flows from the summit or flank,
- 5) cone collapse, resulting in a debris avalanche, or
- 6) formation of a new satellite vent.

Phreatomagmatic eruptions are likely the greatest short term hazard, but sector collapse of the volcano may be the most potentially destructive hazard. Collapse of the Crater Lake wall is likely the second greatest risk (see Section 2.3 for detailed discussion). It is likely that future eruptions will occur from the same general area as historical eruptions (Neall et al., 1995), however there is no way of accurately predicting the location of future activity, as other flank and summit vents may also be possible sites for future volcanism (Houghton et al., 1987). This uncertainty adds a further complication to eruption response planning at the ski areas, as it is possible a different style of eruption may occur which would make a response plan for lahars unnecessary, as ballistic bombs or avalanches may become the biggest hazard.

### 2.2.4 *Hazard Zones*

Houghton et al. (1987) have assessed the hazard zones for phreatomagmatic eruption events at Ruapehu of differing frequency. Their results are as follows:

- The events with the lowest relative risk are phreatomagmatic eruptions occurring at a 1 to 3 year (or greater) frequency. The only real hazard is to anyone who may be in the Crater Lake basin being struck by a ballistic block. Skiing could be disrupted by ash fall (Figure 2.3a).
- Greater risks occur with eruptions of frequency 10 to 30 years. Within 1 kilometre of the Crater Lake, risk is extreme as ballistic blocks will likely exceed 1 per 10 m<sup>2</sup> and few people in this area would survive. Between 5% and 30% of the water from Crater Lake would be ejected, elevating lahar risk. The resulting lahars would likely be moving fast enough to damage bridges and buildings. As the slope lessens, the lahars will become more flood-like. Minor damage can be expected on Whakapapa ski area, increasing if a southerly wind is present. Damage to road and rail is unlikely, but ash fall may extend 10 to 30 kilometres downwind (Figure 2.3b).

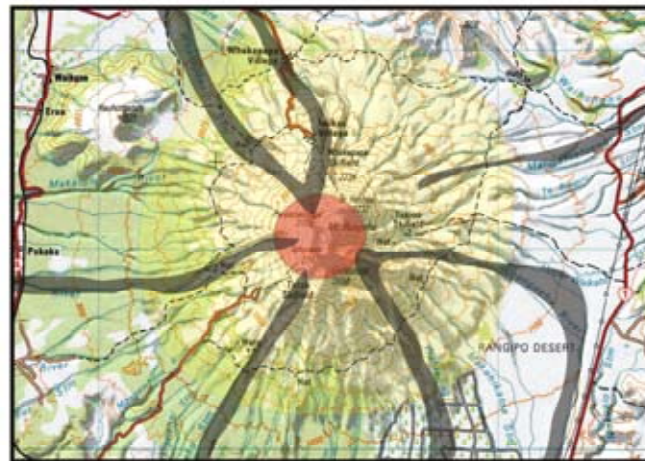
- A larger area is covered by eruptions occurring at a 100 year frequency. The summit hazard zone will likely cover 3 kilometres, with a high abundance of ballistic blocks in this area. There is also the potential in this region for destructive surges. Large lahars will likely be created, damaging areas in valleys downwind of the vent. A southerly wind would result in damage from lahars to Whakapapa ski area and destruction of bridges. Ash fall would extend 100 kilometres downwind, causing serious problems to areas on or near the mountain as 10 centimetres may accumulate (Figure 2.3c).
- The lahar risk from a 400-500 year eruption (similar to the 407 and 756 year B.P. lahars) would be extreme as 80% to 100% of the Crater Lake water may be ejected. It is possible that such a large lahar would either damage or destroy Iwikau village (part of Whakapapa ski area).

Therefore it is possible that the most frequently occurring style of eruption may not affect the ski areas, particularly if the wind is not blowing the right way. This produces a very dynamic decision-making environment, as different style and frequency eruption events may occur which may or may not affect the ski area.





A. Zones of volcanic risk associated with phreatomagmatic eruptions of frequency 1 to 3 years



B. Zones of volcanic risk associated with phreatomagmatic eruptions of frequency 10 to 30 years



C. Zones of volcanic risk associated with phreatomagmatic eruptions of frequency 100 years

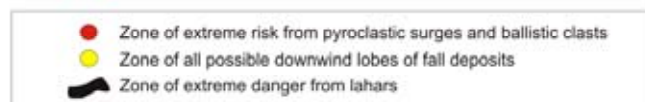


Figure 2.3 Zones of volcanic risk associated with different frequency events at Ruapehu (modified from Houghton et al., 1987)

### 2.3 Crater Lake Tephra Barrier Failure

The 1995/1996 eruptions of Ruapehu deposited a tephra layer at the Ruapehu Crater Lake outlet. The tephra barrier has allowed the Crater Lake to fill to 7 metres above its former level. However, the tephra barrier is highly permeable and relatively weak. Water from the Crater Lake will likely seep through the permeable layers of the barrier and erode it internally, causing the barrier to fail, releasing 1.4 million m<sup>3</sup> of water into the Whangaehu valley. The release of this water could generate a lahar that would travel down the Whangaehu river valley (Figure 2.4), similar to the lahar of the 1953 Tangiwai rail disaster. However due to glacial recession, the resulting lahar from a tephra barrier failure could be much larger (50 to 75%) than the Tangiwai lahar (Galley et al., 2004).

Confusion has arisen between a lahar produced by the failure of the Crater Lake tephra barrier and an eruption-produced lahar. A lahar produced by the failure of the tephra barrier poses no hazard to any of the ski areas (Leonard et al., 2004). However, misconception of risk may affect the ski areas indirectly as skiers may choose to stay away by thinking an event is imminent.

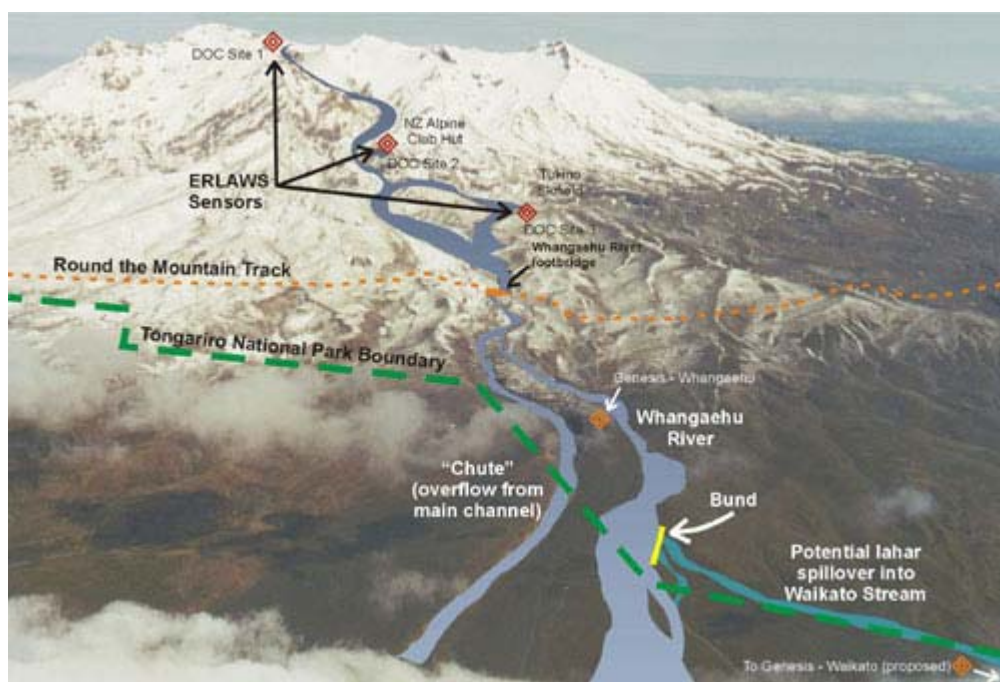


Figure 2.4 Path of Crater Lake tephra barrier failure lahar and associated warning system (Department of Conservation, 2006)

## 2.4 Engineering Mitigation at Crater Lake

A commonly mentioned solution to the lahar problem at Ruapehu is to use engineering mitigation to remove the threat, such as draining the crater lake. In 1999, twenty-three options were considered in a report to the Minister of Conservation (Department of Conservation, 2006). These options fell into six categories (Department of Conservation, 2003a):

1. No engineering mitigation,
2. Intervention only in lahar flood run-out zone,
3. Stabilising the dam over the Crater Lake outlet,
4. Excavate a trench through the Crater Lake dam,
5. Excavate a trench into the underlying lava at the dam outlet, or
6. Other options: siphoning, barrier truss.

While these options aimed at reducing the risk of a Crater Lake tephra barrier breakout, they would also reduce the lahar risk on the ski areas by lowering the level of the Crater Lake, thereby lowering the amount of water available to be ejected by an eruption and likely reducing the size of resulting ski area lahars.

It was decided by the Minister of Conservation that no engineering mitigation would take place at the Crater Lake. This was due to the impact of several factors, including cultural and religious implications, as well as the notable risks to operator safety while taking out these mitigations (Department of Conservation, 2003a). A major factor in the decision was the Ngati Rangi, whose tribal area includes the southern part of Ruapehu. They released the following statement:

*“Ngati Rangi unilaterally opposes any interference with the natural landscape created by the 1995-96 eruptive forces on the peaks of Mount Ruapehu and see it as a cultural affront and a major degradation of the sacred regard in which Ngati Rangi hold their mountain peaks to even consider any option that would seek to artificially alter that mountain landscape.”* (Department of Conservation, 2003b, p. 1)

The decision of the Minister of Conservation was to install a reliable warning system, ensure emergency response systems were in place, and to construct a bund to prevent overflow into the Tongariro River (Department of Conservation, 2003a), which have all been completed.



## Chapter Three

# Background Information on Skiing at Ruapehu

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The beginning of this chapter includes a brief summary of ski areas on volcanoes worldwide to give the reader an indication of the uniqueness of the situation at Ruapehu. The ski area company, Ruapehu Alpine Lifts, is introduced, and a brief history of the company is presented including recent skier numbers. Potential volcanic hazards to the ski area are then discussed specifically. Impacts of the 1945, 1969, 1975, and 1996/96 eruptions on the ski area are also outlined, including the impact of similar eruptions on the present-day ski area. The history of lahar warning systems at the ski area is also presented, and the Eruption Detection System (EDS) is introduced.

### **3. BACKGROUND INFORMATION ON SKIING AT RUAPEHU**

#### **3.1 Worldwide ski areas on volcanoes**

The problem at Ruapehu is not a unique one, as Keys (1997) has identified developed ski areas on 25 active volcanoes worldwide (Table 3.1). All are known to erupt explosively, however vary in eruption styles and magma composition. Half of these volcanoes are found in Japan, which is where the only known volcanic activity-caused deaths of downhill skiers worldwide occurred on Kusatsu-Shirane, where nine skiers have been poisoned and killed by volcanic gas on two separate occasions. A cross-country skier at Mammoth Mountain was likely killed by volcanic gas in 1998 (The Star-Ledger, 2005). However, non-skier fatalities have occurred on several of the volcanoes identified. Keys (1997) finds the presence of active volcanoes and ski areas no coincidence, as it is

related to “the presence of suitable snow-covered terrain provided by volcanoes and the demand for ski facilities, together with a lack of suitable terrain on inactive or non-volcanic areas” (p. 66).

Ruapehu and Kusatsu-Shirane are the only active volcanoes with technological systems for direct warnings of volcanic hazards on ski areas. Kusatsu-Shirane’s system is a gas alarm system.

Keys (1997) also found that risk management styles on the active volcanoes are similar in the various countries. All areas have plans for either restricting access during active periods or have warning systems in place. However, the degree to which this is pursued by officials is questionable. He also found that the extent of risk management is based partly on the magnitude of the hazard, as well as the number of people at risk. Walker (1997) followed Keys’ study with a more detailed investigation into volcanic management plans for ski resorts on 7 selected volcanoes, which included Ruapehu. It was found that while most ski resorts were aware they were located on an active volcano, volcanic management plans ranged from being acceptable to unacceptable (Table 3.1). Whakapapa was the only ski resort with a specific hazard management strategy, however success of the plan was dependent on acknowledgement of the problem and acceptance by customers. Walker (1997) believes that money and advanced technology available in developed countries yields a more detailed and complete system. But the system is only a ‘good one’ if it facilitates timely action to safeguard life and property (i.e. warning and time to protect ski area infrastructure).

Volcano	Height (metres)	Location	Eruptions in 19 <sup>th</sup> century	Eruptions in 20 <sup>th</sup> century (No. fatal)	Causes of death	Main victims	Current Volcanic Response Plan
Adataru	1718	Honshu, Japan	1-2	3 (2)	tephra, gas	72 miners in crater, hikers	
Akita-Komogatake	1637	Honshu, Japan	1	2-3(0)	-	-	
Antuco	3585	Central Chile	11	0	-	-	
Asama	2560	Honshu, Japan	10-11	45- 47 (9)	tephra, pyroclastic flows	climbers, townsfolk	
Aso-caldara (Nakadake)	1592	Kyushu, Japan	23	65-68 (5)	tephra, pyrosurge, Gas?	workers, tourists	
Avachinsky	2741	Kamchatka	6-7	7-9 (0)	-	-	
Azuma	2024	Honshu, Japan	3-6	4(0)	-		
Baker	3285	Washington, USA	8-17	9 (1975=steam)	-	-	acceptable
Bandai	1819	Honshu, Japan	1-2	0	-	-	
Chillan	3212	Central Chile	5-7	3(1)	lahars	townsfolk	unacceptable
Copahue	2965	Chile-Argentina	0-1	3(0)	-	-	
Etna	3350	Sicily	34-35	71-72 (3)	lava, tephra	townsfolk, tourists	
Hood	3426	Oregon, USA	2-6	0-1 (0)	-	-	unacceptable
Iwate	2041	Honshu, Japan	0	1(0)	-	-	
Kurikoma	1628	Honshu, Japan	0	3(0)	-	-	
Kusatsu-Shirane	2176	Honshu, Japan	3	14-18 (3)	lahar, gas	miners, 6 skiers, tourists	
Lassen	3187	California, USA	0-1	1 (0)	-	-	unacceptable
Llaima	3125	Central Chile	15-16	27-28 (1)	lahar	residents	
Lonquimay	2865	Central Chile	1-2	2-3 (1)	tephra poison	woodsman	
Mammoth Mountain	3369	California, USA	0	0 (recent unrest) (1)	gas, tephra, pyroclastic flow	cross-country skier	
Nasu (Chausudake)	1917	Honshu, Japan	2	3-4 (0)	-	-	
Nikko-Shirane	2578	Honshu, Japan	3-4	0	-	-	
Ontake	3063	Honshu, Japan	0	1 (0)	-	-	
Osorno	2652	Southern Chile	5	0	-	-	
Ruapehu	2797	New Zealand	3 from 1861	47-48 (1)	lahar	train disaster	acceptable, but needs work
Tokachi	2077	Hokkaido, Japan	3	14 (2)	lahars, blocks	various (no skiers)	
Villarrica	2840	Central Chile	17-19	24-25 (4)	lahars	townsfolk	unacceptable
Zao	1841	Honshu, Japan	14-16	2-4(0)	-	-	

Table 3.1 Active volcanoes with developed ski areas on their slopes (from Keys, 1997). The volcanoes listed have all erupted in the 19th or 20th centuries and are therefore regarded as active. Includes eruptions up to 1994 (and the 1995/96 eruption at Ruapehu).



### 3.2 Ruapehu Alpine Lifts

Skiing on Ruapehu started in 1913 when William Mead and Bernard Drake formed the Ruapehu Ski Club. The first rope tow was installed on the mountain in 1929, and twenty years later membership in the Ruapehu Ski club was 1,000. Ruapehu Alpine Lifts was formed in 1953 as a public company to develop ski facilities at Whakapapa, with any profit from the company being put back into improving facilities at Whakapapa. In 1954 the first chairlift in New Zealand was installed at Whakapapa. This led to a building boom at Iwikau Village and the development opened the mountain not only to skiers but also to sightseers. More lifts were constructed in the 1960s and by 1966 there were 170,000 visitors per year, an increase of 700% from when the first chairlift was built back in 1954. The early years were very hard for RAL, as the company had to deal with the consequences of lahars, lightning, and ice (Williams and Bamford, 1987). The first tow rope was built on the south slopes of Ruapehu in 1962, and Turoa emerged as a major ski area on Ruapehu in 1978 (Ruapehu Alpine Lifts, 2005a). Ski facilities continued to increase at Whakapapa ski area, and in 1987 the capacity of ski lifts and T-Bars was 20,000 skiers per hour (Williams and Bamford, 1987). After the 1995/96 eruptions, New Zealand Ski Fields Ltd, operators of Turoa ski area, sold their operation license to RAL. RAL currently operates the two biggest ski areas on Ruapehu, Turoa and Whakapapa ski areas.

Currently, Whakapapa is the largest ski area in New Zealand (in terms of skiing area), and Turoa is the highest ski area in New Zealand. The company employs approximately 70 permanent staff, and expands to 750 staff for the winter seasons as 600 to 700 seasonal staff are added. Ski area statistics for Whakapapa and Turoa are as follows (Table 3.2).

	<b>Whakapapa</b>	<b>Turoa</b>
<b>Typical Season Duration</b>	Late June to mid November	Late June to mid November
<b>Chairlifts</b>	5 Double, 2 Quad	2 Quad, 2 Triple
<b>T-Bars</b>	4	2
<b>Platters</b>	2	3
<b>Learners Ropes</b>	1	
<b>Base Area Altitude</b>	1630 metres	1600 metres
<b>Highest point</b>	2300 metres	2322 metres
<b>Area</b>	550 hectares	500 hectares
<b>Access Road</b>	6 kilometres, sealed	17 kilometres, sealed
<b>Cafes</b>	6	3
<b>Retail Shops</b>	2	1
<b>Snow Groomers</b>	8	5
<b>Instructors</b>	126	60

Table 3.2 Ruapehu ski area statistics (Ruapehu Alpine Lifts, 2005a)

Skier numbers have also increased on Whakapapa and Turoa since the 1995/96 eruptions (Figure 3.1). The 2004 season had the highest winter patronage (239,000) since 1992 at Whakapapa, and the highest number ever for Turoa (176,400). International visitors were also up 27%. Whakapapa had 75,000 visits by beginner skiers, and Turoa had 25,000 (Milne, 2005b). The 2004/2005 summer season for Whakapapa was 21,500 (Figure 3.2). Overall, patronage at Whakapapa and Turoa ski areas has been generally increasing since the 1995/96 eruptions.

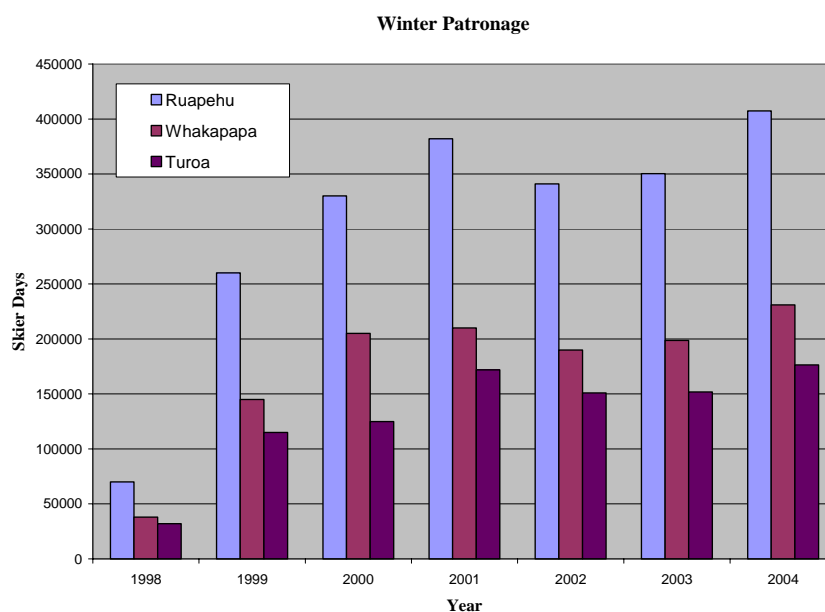


Figure 3.1 Winter Patronage at Whakapapa and Turoa ski areas (Ruapehu Alpine Lifts 2003, 2004, 2005b)

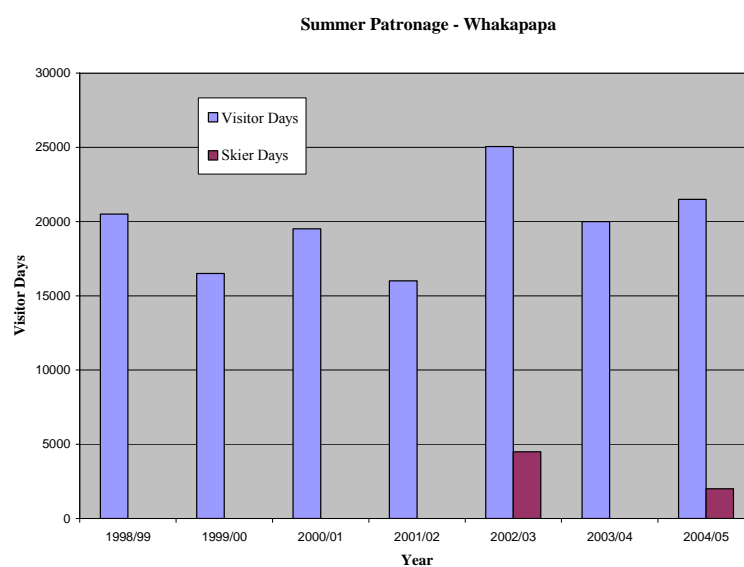


Figure 3.2 Summer patronage at Whakapapa ski area (Ruapehu Alpine Lifts 2003, 2004, 2005b)



The 2005 season is also looking promising, as 25,000 season passes were sold in the pre-season, up on the 22,000 sold in 2004 (Milne, 2005b). It is likely that numbers will keep increasing, as there are numerous plans to update the current development at the ski areas. The following changes have been proposed (Milne, 2005a):

1. Expand beginner area at top of Centennial chairlift at Whakapapa,
2. Install a gondola to provide easier access to the Far West area at Whakapapa,
3. Install magic carpet beginner lifts at Whakapapa and Turoa,
4. Increase the café size at Turoa at the top of the Movenpick to 500 seats,
5. Increase Alpine Meadow beginner area at Turoa, and
6. Install an 8-seater chairlift to replace the High Noon T-Bar at Turoa.

By increasing the number of facilities on the ski areas, the numbers of customers and staff present each day will also increase. This contributes to a rising risk to human life by a volcanic event each year at the ski areas, as more people being present on the mountain increases the probability for one or more to be affected. The current layouts of the base areas and trail maps of both ski areas can be found in Appendix 7.

The length of the winter season at Whakapapa and Turoa ski areas is generally about four months, with the Upper Mountain of the ski areas being open approximately 70% of those days and the Lower Mountain being open approximately 90% of the time (Table 3.3). These times of the year are therefore the times when the likelihood of a death occurring on Ruapehu from a volcanic event increases substantially.

Table 3.3 Length of winter ski season at Turoa and Whakapapa  
(Ruapehu Alpine Lifts 2003, 2004, and 2005)

Length of Winter Season					
		Opening date	Closing date	Days Available	Days open
Upper Mountain					
2004	Whakapapa	July 06	Oct 31	118	68%
	Turoa	June 24	Nov 21	151	66%
2003	Whakapapa	July 13	Nov 16	127	65%
	Turoa	June 27	Nov 16	143	63%
2002	Whakapapa	June 29	Oct 28	122	63%
	Turoa	June 21	Nov 10	143	59%
2001	Whakapapa	July 4	Oct 28	116	79%
	Turoa	June 25	Oct 28	125	76%
Happy Valley/Alpine Meadow					
2004	Whakapapa	June 25	Oct 10	108	92%
	Turoa	June 23	Oct 24	124	81%
2003	Whakapapa	June 28	Oct 5	100	89%
	Turoa	June 20	Oct 29	132	83%
2002	Whakapapa	July 12	Oct 3	87	93%
	Turoa	July 3	Oct 13	103	74%
2001	Whakapapa	June 22	Oct 6	107	99%
	Turoa	June 22	Oct 6	107	94%

### 3.3 Potential hazards from Ruapehu

#### 3.3.1 Lahars

Lahars are the main volcanic hazard on Ruapehu in the early stages of an eruption (Johnston et al., 2000), and are the greatest volcanic threat to life and property at Whakapapa ski area (Leonard et al., 2004). Lahar is an Indonesian word meaning a slurry of water and volcanic debris that flows down the side of a volcano. At Ruapehu, lahars are specifically created by the mixing of ejected rocks and lake water with snow (Nairn et al., 1996). Lahars may occur during an eruption or be a secondary occurrence as volcanic debris may be re-mobilised during heavy rainfall. Lahars may also occur by overflow of a crater lake, which may or may not be triggered by a volcanic event. Death is generally caused by severe crush injuries, drowning, or asphyxiation (Johnston and Houghton, 1995). Nearly all major eruptions in the historical record at Ruapehu have produced lahars, draining into valleys around the summit (Nairn et al., 1996). Ruapehu is unique internationally as lahars on the mountain are produced by depositing water from a Crater Lake onto surrounding snow/ice (Otway et al., 1995).



Figure 3.3 1995 eruption lahars down Whakapapa ski area, viewed from above the Crater Lake (Photograph from GNS)



Figure 3.4 Lahar at Mt. St. Helens, produced by melted snow from the March 21, 1982 eruption  
(Photograph by Tom Casadevall, March 21, 1982, USGS)



Figure 3.5 Damage done by a lahar at Mt. St. Helens  
(Photograph by Don Swanson, May 19, 1980, USGS)

Lahars at Ruapehu most commonly run down the Whangaehu river valley, but can also run down the Whakapapaiti and Whakapapanui valleys to affect the ski areas. Recent lahars on Ruapehu originated by two processes. The first is by collapse of the tephra barrier on the edge of Crater Lake to form a lahar which typically travels down the Whangaehu valley (see Section 2.3 for a more detailed explanation). The second process involves an explosive eruption which ejects contents of the Crater Lake onto surrounding snow/ice/rock, and the mixture will begin to flow downslope (Otway et al., 1995). In order to get lahars in the Whakapapaiti and Whakapapanui valleys, which will affect the ski area, a northerly headwind must prevail to direct the surge into these headwaters (Otway et al., 1995) or the eruption must be laterally-directed towards these drainage basins, as occurred in the 1995 eruption (Department of Conservation, 1996).

### 3.3.2 Ballistic bombs

Another threat on Ruapehu is the ejection of rocks during an eruption from the vent. These rocks are known as ballistic bombs or blocks, depending on their angularity. They follow ballistic trajectories and can be highly damaging. Generally, they land within 2 kilometres of the vent from which they were ejected (Johnston and Houghton, 1995). Therefore, they can be hazardous to anyone or anything within 2 kilometres, but are of low risk to anyone outside this zone. This area of high hazard at Ruapehu is known as the Summit Hazard Zone, and can be easily managed during periods of volcanic activity by simply restricting access to the area (Sherburn and Bryan, 1999). The two upper chairlifts of Turoa ski area fall within this 2 kilometre Summit Hazard Zone. The zone also passes close to the top of the Far West T-bar on Whakapapa. However, in the event of a 100-year frequency eruption, this Summit Hazard Zone would increase to 3 kilometres (Houghton et al., 1987). There would be little chance of survival in this area. This 3 kilometre Summit Hazard Zone would extend further down into Whakapapa and Turoa ski areas, increasing the hazard for people on the ski area. This Summit Hazard zone continues to increase in distance from the crater as the frequency of event decreases (Houghton et al., 1987).

### 3.3.3 Ash fall

Ash fall is a common hazard occurring with eruptions from Ruapehu and can affect a large area, particularly downwind of the eruption. Ash from the 1995 eruption fell on Hastings (Johnston et al., 2000), which is approximately 120 kilometres from the vent. The impacts of ash falls on structures, people, and equipment will vary depending on the thickness of the ash layer. Ash fall can severely disrupt infrastructure in the effected areas, for instance by polluting water supplies, causing vehicle damage, reducing visibility, covering roads which effects vehicle traction, and disrupting electrical supplies (Johnston and Houghton, 1995). In a large eruption (frequency 100-year) it is likely that the zone of ash fall will extend for 100 kilometres downwind, particularly causing problems for areas close to the mountain (Houghton et al., 1987). Ash fall could adversely affect the surrounding area including: closing the ski areas, closing the Desert Road, severely disrupting the electricity supply, pose problems for power scheme intakes, tunnels and equipments, disrupt the NZ Army's activities, and ruin the trout fishing in surrounding rivers (Neall et al., 1995). Ash fall on the snow at the ski area would disrupt skiing until subsequent snowfall occurs. Ash is not usually a direct cause of loss of life, but it can act as an irritant affecting the eyes and throat (Johnston and Houghton, 1995).

### *3.3.4 Volcanic Gases*

Volcanic gases may also be hazardous during an eruption episode. Volcanic gases are continuous products of volcanic activity, and eruptions may produce lethal quantities. Besides being dangerous to humans, volcanic gases also affect the regional and global environment. Commonly emitted volcanic gases include carbon dioxide (CO<sub>2</sub>), sulphur dioxide (SO<sub>2</sub>), hydrogen sulphide (H<sub>2</sub>S), radon (Rn), hydrochloric acid (HCl), hydrofluoric acid (HF), and sulphuric acid (H<sub>2</sub>SO<sub>4</sub>) (Williams-Jones and Rymer, 2000). Concentration of the gases in the air decreases as distance from the source increases, so threat is only posed to areas within a few kilometres of the eruption vent. Volcanic gases can affect respiration and eyes, and can also corrode metals (Johnston and Houghton, 1995). Volcanic gases can cause acid rain, which may damage equipment on the ski areas over time.

### *3.3.5 Avalanches*

Avalanches can also be a hazard during an eruption, particularly to the ski areas. It is possible for a large explosive eruption to trigger wet slab avalanches from steep areas of the mountain, or possibly elsewhere depending on the stability of the snow pack (Otway et al., 1995).

### *3.3.6 Pyroclastic flows*

Another hazard from a volcanic eruption is the generation of pyroclastic flows. A pyroclastic flow is a “laterally transported, fluidized mass of hot dry rock fragments mixed with hot gases” which moves away from the volcano at very high speeds (Lipman, 2000). Anyone caught in a pyroclastic flow will likely die or be severely injured. Dome collapses during a magmatic eruption at Ruapehu are likely to cause pyroclastic avalanches and/or hot, dry pyroclastic surges (Houghton et al., 1987).

Historically, pyroclastic flows have not been seen on Ruapehu. However, new geological evidence suggests that pyroclastic flows have occurred on Ruapehu in the past, particularly during the Taurewa eruptive episode which consisted of closely spaced Plinian eruptions (10,500 years B.P.). Therefore there is potential for another pyroclastic flow to occur on Ruapehu, although it is likely that these events would be very infrequent, possibly on time scales of thousands of years (Donoghue et al., 1999).

### 3.4 Impacts of eruptions on Ruapehu ski areas

Knowledge of the characteristics and consequences of previous eruptions provides invaluable input into defining the context in which response activities could take place. This information also identifies the range/diversity of hazard consequences. Ski area staff will need to understand this, and use this knowledge to develop contingent decision competencies to deal with emergent and possibly rapidly changing circumstances (Paton and Flin, 1999; Paton and Jackson, 2002).

#### 3.4.1 1945

In March 1945, a viscous andesitic lava dome began growing in the Crater Lake, slowly displacing the water through a natural outlet into the Whangaehu Valley (Williams, 1986). A large eruption was observed on March 26<sup>th</sup> and then activity was relatively quiet throughout April. The first two weeks of May saw steam and ash emitted in a continuous column, however the lava dome appeared to stop growing in the second half of May. Activity increased in June and the lava dome continued to grow, entirely displacing the Crater Lake. On July 1<sup>st</sup>, two trampers were injured when an explosion showered them with hot rocks. One was knocked unconscious and both received burns (Johnston and Neall, 1995). After the lake had disappeared, explosive activity began to commence starting in August, 1945 and continuing until November, 1945. The main hazard was ejection of volcanic blocks landing up to 1.5 kilometres from the crater and ash fall (Williams, 1986). At the end of August, skiing on Ruapehu was abandoned due to ash fall (Johnston and Neall, 1995).

If this eruption were to have occurred during the present day ski season in the middle of the day, it is likely the ski areas would be quickly evacuated and the biggest hazard to customers, staff, and infrastructure would be ash fall.

#### 3.4.2 1969

The eruption sequence began on 22 June 1969, just after midnight, and 29 minutes after seismic tremor had begun (Williams, 1986). The Dome seismograph was destroyed soon after, likely by the main eruption which was accompanied by a  $M_L$  3.5 volcanic earthquake (Otway et al., 1995). The large eruption resulted in 30% of the Crater Lake being ejected (Williams, 1986). Southerly winds caused the majority of ejecta to be deposited in the Whakapapanui and Whakapapaiti catchments, creating lahars in the Whakapapanui, Whakapapaiti, Mangaturuturu, and Whangaehu valleys, and later flooding in the Whakapapa area. The lahar passed through Whakapapa ski area, destroying or



severely damaging the Dome Shelter and the Staircase Kiosk (Figure 3.6). It is estimated that near the top of the Far West T-Bar (about 1 kilometre down from Crater Lake) the velocity of the lahar was  $\sim 17$  m/s (Otway et al., 1995). It is estimated that the lahar was up to 2.5m thick and 30m wide (Williams, 1986), and the total volume of the Whakapapa lahar has been estimated at 117,000 m<sup>3</sup>. Ash arrived at Iwikau Village shortly after (Otway, 1995).



Figure 3.6 Staircase Kiosk (since removed) damaged by 1969 lahar (GNS)

The Ruapehu lahars of the 1969 eruption were easily documented due to clear weather and pre-eruption snow cover. Numerous aerial and ground photographs were taken of the lahars' paths. These paths have been used in lahar hazard planning by the ski area companies (Otway et al., 1995).

If this eruption were to occur during the present-day ski season in the middle of the day, it is possible that hundreds of skiers would be in the lahar path when the eruption would begin. Skiers and staff would then have to respond to the warning system by moving to higher ground. After the lahar passed, it is likely that groups of people would be isolated by the lahar path. The evacuation situation would also be greatly complicated by the immediate prospect of ash fall on the ski area.

### 3.4.3 1975

This eruption began early on 24 April 1975. A  $M_L$  4 earthquake was recorded but the actual eruption was not observed. It is estimated the explosion was equivalent to the detonation of about 20 kilotons of high explosive (Williams, 1986). Lahars were created in the Whakapapanui, Whakapapaiti, Mangaturuturu, and Whangaehu valleys, as 25% of the water in the Crater Lake was

ejected (Williams, 1986). Water passed through the “Notch” of the Central Crater, flowing onto the Whakapapanui glacier down through the Whakapapa ski area. The lahar passed to the east of and below the Staircase Kiosk and beneath the Waterfall chairlift and T-Bar terminals (Figure 3.7).

Damage was done to all three buildings. The total volume of the Whakapapa lahar was estimated at 900,000 m<sup>3</sup>. Another eruption occurred on 27 April 1975, but only one lahar down the Whangaehu glacier was generated (Otway et al., 1995).



Figure 3.7 Chairlift (since removed) damaged by 1975 lahar (GNS)

If this eruption would occur during the present-day ski season in the middle of the day, there is potential for hundreds of skiers to be in the path of the lahar when the alarm sounds. To survive, skiers would either have to know the correct response actions (move to higher ground) or be instructed to do so by staff. Groups of skiers and staff may be isolated by the lahar paths, complicating the evacuation. Infrastructure damage would likely be inconsequential, as structures damaged by this lahar have since been removed.

#### *3.4.4 1995 and 1996*

This eruption sequence began in the morning on 18 September 1995, although it was not seen due to bad weather. A large lahar was seen in the Whangaehu River from the Tukino ski area. On Saturday 23 September 1995, there were many skiers on the ski areas during the day due to good weather. The largest eruption of the sequence began an hour after the ski areas had closed. Ballistics were thrown 1 kilometre from the vent. Lahars were created in the Whangaehu, Mangaturuturu, and Whakapapaiti drainage basins (Department of Conservation, 1996). Two separate lahars entered the western areas of Whakapapa ski area within 90 seconds of the eruption (Nairn et al., 1996). One ran down the Outer Limits/Three Boys Bowl run. The second lahar ran through the Turn Pipe run into the Far West ski area, and exited out through Turner's Valley



(Department of Conservation, 1996) (Figure 3.8). The Lahar Warning System for the ski area was never triggered (Nairn et al., 1996; Sherburn and Bryan, 1999).



Figure 3.8 Far West T-Bar and 1995 lahars (GNS)

If this eruption was to occur during the present-day ski season in the middle of the day, it is likely that hundreds, if not thousands, of skiers would be in the popular Far West area, including many out-of-bounds skiers. Due to the alarm not sounding, and the short time between the eruption and the entry of the lahars into the ski area (estimated 90 seconds), it is likely that many skiers would remain in the lahar path, resulting in a high casualty rate. Evacuation of the Far West area would be complicated by the presence of the lahar paths, as well as the relative isolation of the area from the rest of the ski area.

On 25 September 1995, Tukino ski area was closed for the season due to ash fall (Department of Conservation, 1996). The largest lahars of the eruption sequence occurred in the Whangaehu valley (Nairn et al., 1995). Ash fall occurred into October, and on 2 October 1995 Turoa ski area received a thin layer of this ash. The area was able to stay open due to following snowfalls. On 13 October 1995, ash eruptions intensified and subsequent ash fall covered the Whakapapa ski area, which then closed for the season (Department of Conservation, 1996). Later in October, a secondary debris flow occurred on the Whakapapa ski area, running down the Gut and coming within 120 metres of the Waterfall T-Bar drive station (Department of Conservation, 1996)

If this secondary debris flow were to occur during the present-day ski season in the middle of the day, it is likely that ten to fifty skiers may be present in the queue lines near the Waterfall drive station (Figure 3.9), as well as skiers in the Gut. There would be many injuries/casualties, as there is no warning system to warn of secondary debris flows, so skiers and staff would be caught off-guard.

Figure 3.9 Waterfall T-Bar drive station, 2005 winter season



Strong gas emission continued into November (Department of Conservation, 1996). By the end of the eruptions, the Crater Lake (10 million m<sup>3</sup>) was completely empty. Secondary lahars occurred as spring rainfall and snowmelt remobilized the ash and scoria at the top of Ruapehu, though none affected any of the ski areas (Nairn et al., 1996).

A sequence of phreatomagmatic eruptions then occurred on 17 June 1996. Ash from these eruptions spread over most of the North Island, especially to the north and west of the vent. The last eruption was on 1 September 1996. Ash from these eruptions resulted in the closure of all ski areas on Ruapehu for most of the season (Johnston et al., 2000). The eruptions disrupted the ski season and caused large economic losses for the companies through both direct risk-related closure and lack of customers due to public concern. Damage was caused to most facilities on all three areas. Rust damage was severe, particularly to lift towers and galvanized iron fittings. The ski areas

took various mitigation measures to try to limit damage such as: closing lifts, covering motors, sealing drive stations, removing vehicles from the areas, and disconnecting water supplies (Johnston et al., 2000).

### **3.5 Warning systems on Ruapehu**

Warning systems for lahars have been present at Whakapapa ski area since 1984. The first system installed was the Lahar Warning System (LWS), which was operated by the Department of Conservation (DoC). The LWS consisted of “stage 1” and “stage 2” alarms. A stage 1 alarm was produced when an earthquake of magnitude  $M_L \geq 3.6$  occurred near the crater. A stage 2 alarm was generated when the Dome Shelter was destroyed, which would be signalled when the seismic signal from the shelter failed. This alarm consisted of sirens and a pre-recorded warning message which were broadcast over Whakapapa ski area. Sherburn and Bryan (1999) noted the system had some weaknesses. The first was that the LWS could not distinguish between volcano-tectonic earthquakes (which do not accompany eruptions) and volcanic earthquakes (which usually signal an eruption). The second was that the Dome Shelter had to be destroyed or endure significant damage to generate a stage 2 alarm. For the system to be reset, the Dome Shelter and seismic equipment had to be replaced or repaired. There would also be a delay between the initial eruption and the destruction of the Dome Shelter, when the LWS would activate.

The LWS was tested on 23 September 1995, when an eruption produced lahars down the Whakapapa ski areas. However, the Whakapapaiti lahar was caused by a lateral jet from the eruption, which did not destroy the Dome Shelter. Therefore, the warning system was never triggered (Nairn et al., 1996). When the ski area opened later in the season for a few weeks, RAL ski patrollers were used to watch for lahar events (Department of Conservation, 1996). After this incident, it was recommended that the LWS be redesigned, especially to increase warning time for the upper ski area (Department of Conservation, 1996). The Institute of Geological and Nuclear Sciences was commissioned by the Department of Conservation and Ruapehu Alpine Lifts to upgrade the system (Sherburn and Bryan, 1999).

It was decided to name the new system the Eruption Detection System (EDS). The EDS would be used to detect large eruptions that have the potential of producing lahars but may not actually cause a lahar (Department of Conservation, 1996). The EDS uses seismic and acoustic data to detect volcanic eruptions. It relies upon characteristic earthquakes at Ruapehu, and uses this data to

distinguish which earthquakes are associated with volcanic eruptions (Sherburn and Bryan, 1999). Acoustic microphones are used to tell when material is ejected from the crater, allowing the EDS to distinguish volcanic earthquakes accompanied by an eruption and volcanic earthquakes unassociated with a volcanic eruption (Geonet, 2002). If the EDS detects a volcanic earthquake ( $M_L \geq 3$ ) and airwaves, the warning system will be activated. In the past 25 years, all lahar-producing eruptions were associated with volcanic earthquakes  $M_L \geq 3.5$ . However as a fail-safe mechanism volcanic earthquakes of  $M_L \geq 4$  detected with no accompanying acoustic signal will generate the warning system (Sherburn and Bryan, 1999). When the EDS activates, sirens and a broadcast message will be played over Whakapapa ski area (Figure 3.10), warning everyone to move to high ground as lahars may travel down valleys (Geonet, 2002).



Figure 3.10 Siren locations at Whakapapa ski area

The following message is played:

(siren) Move out of the valleys to high ground. Move out of the valleys to high ground.  
 This is a volcanic emergency. This is a volcanic emergency.  
 A lahar is expected to pass through the ski area. A lahar is expected to pass through the ski area.  
 Move out of the valleys to high ground. Move out of the valleys to high ground.  
 Move out of the valleys to high ground. (siren). *Repeats message.*

In the past few years, the EDS has been linked to a pager system which will notify Turoa management that the EDS has been activated (Peter Blaxter, *personal communication*, 2005). Management can then broadcast over the radio and PA systems at Turoa ski area that an eruption is in progress. Whakapapa management will also have pagers, beginning for the



2005 season, in case of failure of the siren speakers (Peter Blaxter, *personal communication*, 2005). The EDS can be seen in Figure 3.11.



Figure 3.11 Eruption Detection System (EDS) which can distinguish between different tectonic events

The EDS is very different from the LWS in that it is proactive in determining when a lahar may be generated to activate the system and does not rely on a lahar already having been generated. The EDS is the only system in the world that attempts to warn of lahars with such a short time for reaction (likely 90 seconds for the upper part of Whakapapa ski area). The EDS operates in near-real time to detect the specific seismic and acoustic signals of a lahar-generating eruption for Ruapehu (Sherburn and Bryan, 1999). However, the EDS has yet to be proven effective during a real event.



## Chapter Four

# Past Research and Eruption Response Plans

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There have been three previous research projects on staff training and public awareness of the volcanic hazards at Whakapapa ski area, and the results of these studies are presented in the beginning section of this chapter. The current public education campaigns at both Turoa and Whakapapa are introduced. CIMS is also explained. A summary of the DoC Eruption Response Plan and the key role of RAL in this plan is introduced and discussed.

### 4. PAST RESEARCH AND ERUPTION RESPONSE PLANS

#### 4.1 Past Research at Whakapapa and Turoa ski areas, Ruapehu

This section contains summaries of previous research done at Whakapapa ski area in regards to staff training and volcanic hazards. The main findings and conclusions of the authors are summarized, and any suggestions or disagreements by this author can be found in the discussion section (Chapters 6 and 7) of this thesis.

##### *4.1.1 Summary of Galley et al. (2003)*

Galley et al. (2003) studied lahar response planning at Whakapapa ski area over the winter of 2000, and they developed a framework for developing a comprehensive response plan for a lahar event at Ruapehu. Galley et al. (2003) acknowledged the eruption may be a 'blue-sky' event, where an

eruption occurs with no warning. Fortunately, although a ‘blue-sky’ event is the most dangerous for the ski field, it is the least likely.

Galley et al. (2003) identified that a lahar event should roughly follow this sequence:

- 1) Eruption begins
- 2) Lahar initiated
- 3) Eruption Detection System (EDS) activated
- 4) Ski-field staff immediately begin moving customers to designated safe areas
- 5) Strategic management command post (CP) personnel begin setting up in designated CP building
- 6) Lahar flow ceases
- 7) Evacuation of ski-field begins – overseen by CP personnel
- 8) CP personnel interacting with outside agencies to gain intelligence on event and coordinate relevant external disaster response agencies, if any (e.g. DoC, ambulance)
- 9) Other personnel setting up various evacuee areas (e.g. general evacuees, those looking for separated family etc, injured evacuees)
- 10) Non-essential personnel in villages evacuating at this time
- 11) Ski-fields are now fully evacuated
- 12) General evacuation of area begins

The operation is therefore divided into four phases:

1. Warning phase
2. Event occurrence and initial response
3. Lahar flow ceases and evacuation of ski field is undertaken
4. Wider evacuation of lower levels and related activities

Galley et al. (2003) also outlined hypothetical events that may follow a lahar. Stage 1 would involve the event occurrence and initial response. At this stage, staff will immediately begin clearing lifts and moving customers to safe areas. Galley et al. (2003) noted that it is important that staff begin immediately to act under their own initiative, and should not seek confirmation from a higher authority. Organisational authority should also be suspended in favour of lower-level decision making until later in the event, when the authority can be gradually transferred to those in more decision making roles. The latter, if the event is prolonged, would deal with strategic recovery issues and leave operational issues to those with the requisite knowledge (Paton, 1997). If staff act immediately to take control, there will be less room for panic and counter-productive actions by customers. Staff should then wait in safe zones until the “All-clear” is given, and staff must be proactive during this waiting period in providing information and reassuring customers.



Stage 2 of events would involve the cessation of lahar flow and evacuation of the ski field. Galley et al. (2003) identifies two options that RAL may select from to evacuate the ski field:

- All staff and skiers may begin to evacuate as soon as permission is given. This will be the fastest option, but there are risks of bottlenecks forming
- Groups will stay in their safe areas until they are specifically instructed to start evacuating. This option will be slower but will likely be safer. However, it may break down under pressure because it will require more organization.

Galley et al. (2003) also suggested that potential evacuation routes from threatened areas be considered in advance, with a single best option being decided upon. Galley et al. (2003) identified a number of stressors staff may have to deal with at this stage, such as dealing with serious injuries, separated family members, differing ability levels of customers, difference in mobility, individuals responding adversely to the situations, and becoming the focus of unreasonable demands and/or targets of blame.

According to Galley et al. (2003), stage 3 will involve an evacuation of lower levels, and will be the responsibility of DoC. Symptoms related to stress and trauma may also begin to manifest, and provision of optional counselling should be made available to staff.

Galley et al. (2003) suggested that when developing the emergency plan, all groups that may be potentially involved must be identified, and their roles and tasks defined. Galley et al. (2003) acknowledge that people will function better in an emergency if they know in advance what to do, but stresses that this does not mean developing a long list of details of individual actions. Rather, a clear role description should be provided, allowing individuals to use common sense to carry out that role. Staff should also be encouraged to act on their own initiative depending on how the situation develops.

Galley et al. (2003) also felt communication would be an essential part of the response plan, and should be developed to use similar communication channels to those typically used by staff. Staff must also communicate what is going on to customers, which will be done best by calmly conveying the gravity of the situation to customers which will improve their willingness to follow instructions. Plans must also be laid out on how to pass scientific information to ski field staff on the status of the eruption. Galley et al. (2003) suggested that establishing a central Command Post (CP) will be crucial to this, as the CP will link personnel on the ski areas to outside agencies. The CP will begin to take control of the ski area once the initial danger has passed.

A survey was undertaken in August 2000 to determine the level of customer understanding of the lahar risk and response. Galley et al. (2003) reported the following results:

- Almost all customers (96%) were aware that Ruapehu was an active volcano and just over half (56%) expected the next volcanic event within the next 10 years.
- Only half (52%) were aware of the lahar warning system.
- Of those aware of the warning system, 86% believed it contained sirens and only 29% were aware of the loudspeaker announcements.
- Of those aware of the system, 79% knew to move to high ground out of the valleys upon receiving a warning.
- Only 21% of customers interviewed claimed they were aware of all the lahar danger zones and another 28% claimed to know some of the zones.

RAL staff were also surveyed but with a very low return rate. Galley et al. (2003) hypothesized this could be seen as an indicator that the level of awareness of the lahar threat was low. However, given the management set-up at the time on the ski area, it is more likely that senior employees gave tangible signals to seasonal staff that the lahar threat was not important.

Galley et al. (2003) also provided the following recommendations for training:

1. Training should include:
  - a. Lectures, first hand accounts,
  - b. Case studies, and
  - c. Audio-visual presentations.
2. Points to cover include:
  - a. The probability of an event,
  - b. The typical build-up scenarios to an eruption,
  - c. The range of potential hazards involved,
  - d. The nature of a lahar, and
  - e. The history of Ruapehu's eruptive activity.
3. The program should strike a balance between giving staff an understanding of the threat and how to respond to it, and overloading them with excess details that will cause confusion.
4. Staff must have realistic performance expectations.
5. Regular simulations must be conducted, followed by a debriefing.
6. The knowledge and skills of staff members must be maintained and updated.

Galley et al. (2003) pointed out that simulations are vital to producing an effective response, especially with the unique situation at the ski areas where there is limited time to train staff. The evacuation plan must also be revised regularly, however Galley et al. (2003) warns that the mere existence of a plan can lead to a false sense of security, and an eventual relaxation in training, vigilance and preparedness.

#### *4.1.2 Summary of Ward et al. (2003)*

Ward et al. (2003) studied staff training at Whakapapa ski area for a lahar response over the winter of 2001. They identified staff training and customer education as being crucial to an effective response. Ward et al. (2003) felt staff training was important, because staff need to respond quickly and effectively to the warning system as the response time is very short before the lahar will enter the ski area. Customer education is also crucial, because if customers know how to respond, they will react sooner without instruction, making the job of RAL staff easier. Ward et al. (2003) identified Ski Patrollers and Lift Operators as being the greatest priority for training, because they are directly involved in the immediate response and will bear the biggest responsibility for moving customers to safe areas. Customer service staff were identified as the next priority, as they are the first point of contact for mountain users and will be crucial during an event for providing information to those both on the ski area and outside.

Ward et al. (2003) observed staff training at RAL over the 2001 ski season. RAL staff training elements in relation to lahars included staff induction, a video, and a staff handbook. Staff received lahar training during new staff induction week. All new staff from all departments attended a one and a half hour session which detailed the lahar paths on the mountain and what to do when the alarm sounds. Ski Patrol staff received more detailed training, but returning staff receive no training. The main training tool during induction week was a ten-minute video from the early 1990's. The video was aimed at informing customers of the lahar dangers, as opposed to training staff. The 2001 staff handbook includes two pages on instructions on response to a lahar warning, however it was aimed at Lift Operators and did not go into detail about how other staff should respond. Ward et al. (2003) also identified training needs for each department at the ski area (Table 4.1 and 4.2).

Table 4.1 Roles of RAL staff in the event of a lahar, from Ward et al. (2003)

	<b>Role: Pre-lahar</b>	<b>Role: During lahar</b>	<b>Role: Post lahar</b>
<b>Ski Patrollers</b>	<ul style="list-style-type: none"> <li>Provide accurate information to any customers enquiring about this hazard</li> </ul>	<ul style="list-style-type: none"> <li>Sweep of high risk areas</li> <li>Move customers to safe areas and assure they stay there, reassure them of their safety</li> </ul>	<ul style="list-style-type: none"> <li>If near shelter in safe area, move there</li> <li>Provide information about location and status of customers to Ski Patrol Manager</li> <li>Attend to those injured</li> <li>Take instructions from Area Two Controller on evacuation of mountain. May also have to take control of a sub-area (see DoC Eruption Response Plan)</li> </ul>
<b>Lift Operators</b>	<ul style="list-style-type: none"> <li>Provide accurate information to any customers enquiring about this hazard</li> </ul>	<ul style="list-style-type: none"> <li>Clear lift, stop lift</li> <li>If in safe area, stay there. Otherwise, move customers to safe area and ensure they stay there, reassure them of their safety</li> </ul>	<ul style="list-style-type: none"> <li>If near shelter in safe area, move there</li> <li>Provide information about location and status of customers to lift operations supervisor</li> <li>Attend to those injured if able, or ensure they are warm and comfortable until help arrives</li> <li>Take instruction from either supervisor or evacuation coordinator on evacuation of mountain.</li> </ul>
<b>Snow School</b>	<ul style="list-style-type: none"> <li>Provide accurate information to any customers enquiring about this hazard</li> </ul>	<ul style="list-style-type: none"> <li>If in safe area, stay there. Otherwise, move customers to safe area and ensure they stay there, reassure them of their safety</li> </ul>	<ul style="list-style-type: none"> <li>If near shelter in safe area, move there</li> <li>If able (e.g. by radio), provide information about location and status of customers</li> <li>Attend to those injured if able, or ensure they are warm and comfortable until help arrives</li> <li>Take instruction from either supervisor or evacuation coordinator on evacuation of mountain.</li> </ul>
<b>Customer Services</b>	<ul style="list-style-type: none"> <li>Provide accurate information to any customers enquiring about this hazard</li> </ul>	<ul style="list-style-type: none"> <li>If customers are around in a safe area, make sure they stay there, reassure them of their safety</li> <li>Begin a register of customers present/missing</li> </ul>	<ul style="list-style-type: none"> <li>Provide up to date information on the status of the mountain and those on it</li> <li>Will likely receive calls from those with friends and relatives on the mountain, need to try and reassure these people as best as possible</li> <li>Avoid making false/uncertain statements</li> </ul>
<b>Food and Beverage</b>	<ul style="list-style-type: none"> <li>Provide accurate information to any customers enquiring about this hazard</li> </ul>	<ul style="list-style-type: none"> <li>Make sure customers in cafes in safe areas stay there, reassure them of their safety</li> <li>Stop serving food, as this may be required to be rationed if evacuation of the mountain is delayed for some time</li> </ul>	<ul style="list-style-type: none"> <li>Provide shelter to those stranded on the mountain</li> <li>Provide food to those stranded on the mountain</li> <li>Begin a register of customers present/missing</li> <li>Provide information about customers present/missing to those coordinating evacuation</li> </ul>
<b>Rental/ Workshop/ Retail</b>	<ul style="list-style-type: none"> <li>Provide accurate information to any customers enquiring about this hazard</li> </ul>	<ul style="list-style-type: none"> <li>If customers are around in a safe area, make sure they stay there, reassure them of their safety</li> </ul>	<ul style="list-style-type: none"> <li>Provide shelter to those stranded on the mountain</li> <li>Begin a register of customers present/missing</li> <li>Provide information about customers present/missing to those coordinating evacuation</li> </ul>
<b>Groomers</b>	<ul style="list-style-type: none"> <li>Less likely to be on mountain during operating times, but must be aware of dangers in order to protect themselves</li> </ul>		

	<b>Table 4.2 Training needs of RAL staff in relation to their roles in the event of a lahar, from Ward et al. (2003)</b>
<b>Ski Patrollers</b>	<ul style="list-style-type: none"> <li>• General information about lahars, including probability of an event, the range of potential hazards involved, safe and high risk areas on the ski field the nature of a lahar, and Ruapehu's eruption history.</li> <li>• Information regarding human response in threatening situations</li> <li>• Awareness of own response to this situation, and how to deal with it after the event is over.</li> <li>• <i>Specific role information</i> – doing a sweep of high risk areas, moving people to safe areas, involvement in evacuation of the mountain, and first aid duties. Ski Patrollers need to be aware of these tasks, and other information pertinent to them, like where the high risk areas are, where safe areas are and the best way to get to them, where shelter is, which radio channel to employ in emergencies. Ski patrollers may also have to take control of sub-areas in Area Two, as outlined in the DoC Eruption Response Plan</li> </ul>
<b>Lift Operators</b>	<ul style="list-style-type: none"> <li>• General information about lahars, including probability of an event, the range of potential hazards involved, safe and high risk areas on the ski field the nature of a lahar, and Ruapehu's eruption history.</li> <li>• Information regarding human response in threatening situations</li> <li>• Awareness of own response to this situation, and how to deal with it after the event is over.</li> <li>• <i>Specific role information</i> – Clearing and stopping lifts, moving people to safe areas, evacuation. Lift operators need to be aware of these tasks, and other information pertinent to them, like which lift queues are in safe/high risk areas, the trouble that may be caused by people getting caught in ropes or tripping over other skis/boards in a crowded area, which radio channel to employ in emergencies, where shelter is, how to keep those injured warm and comfortable until help arrives.</li> </ul>
<b>Snow School</b>	<ul style="list-style-type: none"> <li>• General information about lahars, including probability of an event, the range of potential hazards involved, safe and high risk areas on the ski field the nature of a lahar, and Ruapehu's eruption history.</li> <li>• Information regarding human response in threatening situations</li> <li>• Awareness of own response to this situation, and how to deal with it after the event is over.</li> <li>• <i>Specific role information</i> – moving students and nearby skiers to safe areas, evacuation. Snow School instructors need to be aware of these duties, and other information pertinent to them, like knowing which areas of the ski field are safe/high risk, where shelter is, how to keep those injured warm and comfortable until help arrives</li> </ul>
<b>Customer Services</b>	<ul style="list-style-type: none"> <li>• General information about lahars, including probability of an event, the range of potential hazards involved, safe and high risk areas on the ski field the nature of a lahar, and Ruapehu's eruption history.</li> <li>• Effective communication and human relations skills, with knowledge of how people are likely to respond in a threatening situation, and to a lack of information. Effective information coordination skills</li> <li>• <i>Specific role information</i> – such as the provision of information to the public and coordination of information</li> </ul>
<b>Food and Beverage</b>	<ul style="list-style-type: none"> <li>• General information about lahars, including probability of an event, the range of potential hazards involved, safe and high risk areas on the ski field the nature of a lahar, and Ruapehu's eruption history.</li> <li>• Effective communication and human relations skills, with knowledge of how people are likely to respond in a threatening situation</li> <li>• <i>Specific role information</i> – involvement in provision of shelter and food to those stranded on the mountain, making sure customers remain in safe areas, involvement in the evacuation of the mountain</li> </ul>
<b>Rental/ Workshop/ Retail</b>	<ul style="list-style-type: none"> <li>• General information about lahars, including probability of an event, the range of potential hazards involved, safe and high risk areas on the ski field the nature of a lahar, and Ruapehu's eruption history.</li> <li>• <i>Specific role information</i> – reassuring customers, making sure customers remain in safe areas</li> </ul>
<b>Groomers</b>	<ul style="list-style-type: none"> <li>• General information about lahars, including probability of an event, the range of potential hazards involved, safe and high risk areas on the ski field the nature of a lahar, and Ruapehu's eruption history.</li> </ul>

Ward et al. (2003) developed the following recommendations for training at Whakapapa ski area:

- **1. All staff attend a session at induction on lahar hazards.**
- **2. This session should consist of a video and lecture**  
The current video should be expanded to be a specific staff training tool. It should include (i) video footage of actual lahars and their effect, (ii) an explanation of how lahars are a hazard, (iii) the location of high risk and safe areas as well as the warning time, (iv) how to protect oneself, (v) lahar behaviour, and (vi) information on the history of lahar activity. The lecture should further explain the video contents, including an outline of RAL and DoC response plans, and an outline of each groups' roles. This will help staff to develop a similar schema of the response, hopefully increasing the efficiency of the response in an actual event.
- **3. After the general session staff should be divided into groups: (A) Ski Patrol and Lift Operators and (B) all other staff.**
- **4. The group of Ski Patrol and Lift Operators will receive more role specific information.**  
The action plans for Ski Patrol and Lift Operators must be explained carefully. It will also be important to explain that customers' reactions may not be as simple as may be expected. It is also necessary to make staff aware of some of the feelings that they may experience following an event, as these two groups of staff have increased responsibility.
- **5. Customer Service may also receive more role specific information**  
Customer Service staff will need to learn skills at employing communication and human relation skills in a high pressure situation. Role-playing is the most efficient way at learning these skills. Information on how customers may respond should also be provided.
- **6. A simulation of the response plans should be run under 'perfect' conditions.**  
Due to the limited time to train staff, a simulation is the only comprehensive way to identify issues and gauge demands that will be encountered during a lahar response. It is important the simulation be observed and video-taped, so staff performance can be assessed. The simulation must be run every year, early in the season. A debriefing should follow the simulation, with staff encouraged to give feedback as this participation may increase commitment from staff.
- **7. Training should be evaluated.**  
Training can be evaluated in numerous ways, including (i) asking employees how useful training was, (ii) assessing learning during the simulation, (iii) comparing simulation results with previous years, and (iv) paper-and-pencil knowledge test.

Ward et al. (2003) felt the cost of this training (video development, personnel costs, and simulation assessment) was small compared to the benefit of having staff fully prepared for an effective response to a volcanic crisis and would also help to address obligations of due diligence RAL may have in regards to lahar risk. They also felt management support for integrated training was crucial, as the development may take time. If staff found that management regarded the lahar training as important, it is likely staff will take it more seriously.

Ward et al. (2003) also provided recommendations for customer education of the ski area. They said educational messages should be repeated in a number of different ways and must cater for a wide range of groups. Message content should include the following: (i) a description of the lahar and hazard, (ii) location on areas of high risk and safe areas, (iii) information about on what actions to take, and (iv) warning time before a lahar enters the ski area. The message also should be from a

credible source, consistent, certain, clear, accurate, and sufficient. Education should also be provided to ski lodges. Customer education will also need to be evaluated for its effectiveness, which is more easily done by surveys. Ward et al. (2003) also mentioned that generally hazard information provided to visitors emphasizes that authorities have a degree of control over the situation.

Ward et al. (2003) also reviewed the DoC and RAL Eruption Response Plans. The DoC Eruption Response Plan was a substantial document, but was being re-written at the time. The plan was found to be very vague in places, assuming that the person carrying out certain instructions would know what to do. The RAL Response Plan was not available, however Ward et al. (2003) recommended the following areas be specified in the plan:

- Dealing with customers once the initial threat has passed
- Planning for psychological care for staff after a disastrous event, such as peer support

The 2001 warning system test was also observed. It was found that in most cases staff being observed gave correct instructions to the public – move to higher ground. However, it was also observed that many staff had a poor understanding of the lahar hazard. Five patrollers also were not able to make it to the area they were supposed to be sweeping in the allotted time. Public response was widely varied, with some people following instructions and others reporting a very poor response.

#### *4.1.3 Summary of Leonard et al. (2004)*

Leonard et al. (2004) also reviewed Ward et al. (2003) and Galley et al. (2003), and provided an update of winter 2003 survey results. Leonard et al. (2003) stated that annual testing of the EDS' reliability and effectiveness had occurred during the 2001, 2003, and 2003 ski season. Simulations were performed in 2001 and 2003, with staff being forewarned. The 2002 test was a blind test, which was supposed to be a surprise to staff. However, it was found a few staff suspected something was happening due to high radio activity. Surveys were conducted

by GNS staff and volunteers after each simulation to determine audibility of the alarm in different locations, and comments on staff and customer response.

Leonard et al. (2004) reported that:

- In 2003, the alarm was audible to customers in all cafes on the ski field, besides LBC at the Top of the Bruce, with responses ranging from complacency to concern or confusion. This was compounded by an absence of staff instructions.
- In all three years, Lift Operation staff generally gave the correct instructions to customers: they were in a safe area and they should stay put, or to move to higher ground.
- Response of customers was mixed, indicating confusion over appropriate response actions.

Leonard et al. (2004) indicated that Lift Operation staff have been the most reliable area in terms of performing the correct actions and public satisfaction with the warning system and its operation. However, absence of staff instructions in the cafes reiterated the importance for Food and Beverage staff to be trained in the proper response. Leonard et al. (2004) also pointed out that individuals tended to follow group actions where staff were not present giving direction, and that this group behaviour is inevitable due to uncertainty. One strategy he gave for dealing with this problem would be placing more information on the appropriate actions to take during a lahar alarm on the lift pylons.

The article also includes results of the 2003 public perception survey at Whakapapa ski area. A similar survey was conducted by Galley et al. (2003) in the 2000 ski season. Both these surveys were conducted independently of the EDS annual simulation exercises. Leonard et al. (2004) noted four significant differences between the 2000 and 2003 survey results:

- Decrease in knowledge of lahar paths.
- Decrease in knowledge of the EDS.
- Decreases in awareness of the correct course of action if the EDS is activated, given awareness of the EDS.
- Increase in requests for public EDS education by skiers.

In 2003, respondents were asked to suggest possible improvements to the EDS. Only 32% of respondents made recommendations to improve the EDS, and 70% of these suggestions involved some form of education. The most common suggestion was to post signs dealing with the lahar hazard. The remaining 30% suggestions were to improve the EDS itself.



Leonard et al. (2004) also detailed work in progress at Whakapapa, including the following:

- Ongoing annual testing of the EDS, including surveying of (a) its operational effectiveness, (b) public awareness of the volcanic hazards and (c) public awareness of the EDS.
- Annual lahar awareness surveys.
- Continual discussion between GNS, DoC, and RAL.
- Continual modification to the operation of the EDS. Previous modifications include replacing faulty or poorly directed loud speakers, and changing the announcement from a male to a female voice to improve clarity.
- Public education. A Whakapapa Volcanic Hazards brochure and hazard/safe-zone map was being drafted by GNS. This would be posted across the field, and would also be available digitally. Public education was also being planned for Turoa ski field.

Leonard et al. (2004) indicated the importance of recognizing the Ruapehu lahar hazard in terms of risk to human life, by referring to the Taig Report (Taig, 2002). Taig (2002) calculated that there were similar probabilities for a (a) lahar killing one person on the Whakapapa ski area as there is for a (b) barrier break-out lahar (See Section 2.3 for a more detailed explanation) killing one person. Leonard et al. (2004) pointed out that even though the probabilities are similar, a barrier break-out lahar has received much more media attention and much more public concern than a lahar on the ski area. Taig (2002) believes there are two variables that control the probability of a ski area lahar fatality:

- The reliability of the EDS to trigger an audible warning.
- The percentage of people actually removed from lahar paths.

Leonard et al. (2004) indicated that the EDS is now running near 100% reliability, so the main concern is achieving a 100% evacuation, which could be initiated by staff education and preparedness, public awareness, and research.

Leonard et al. (2004) suggested the following changes:

- Two simulations of the EDS annually
  1. A first beginning-of-season test where the staff are forewarned and which

- therefore serves to motivate them to obtain information on aspects they do not understand. This also serves to check any EDS technical failures.
2. A later season ‘blind’ test with no warning to general staff, to gauge effectiveness of system in terms of public response.
  - Research should be ongoing, including the two main avenues of data collection
  3. The survey of observations and comments on EDS simulation effectiveness should continue annually.
  4. Ongoing annual surveys of the awareness of (a) volcanic hazards and (b) the EDS.

#### **4.2 Public Education for Volcanic Hazards at the ski areas**

A public education poster and brochure series was first introduced at Whakapapa for the 2004 ski season. The public education campaign was designed by the Institute of Geological Sciences (GNS) and the Department of Conservation (DoC), with input from RAL. The goal was to increase public awareness of volcanic hazards at the ski area, specifically to increase knowledge of lahars. The Whakapapa poster (Figure 4.1A) displays graphics of the lahar paths, safe areas and the summit hazard zone, and describes the volcanic hazards, warning system, and correct actions to take during a volcanic event. There is also a picture of the Far West lahars from the 1995 eruption, showing how close it came to the bottom of the Far West T-Bar.

The public education campaign was expanded to include Turoa for the 2005 ski season. The Turoa poster (Figure 4.1B) displays graphics of the lahar paths, safe areas and summit hazard zone, and describes the volcanic hazards and correct actions to take during a volcanic event. There is also mention of the top two T-Bars being in the summit hazard zone.



Figure 4.1 Volcanic Hazards public education posters at *A.* Whakapapa ski area and *B.* Turoa ski area.

Public awareness surveys of the volcanic hazards also continue to be conducted at Whakapapa and Turoa ski areas (Figure 4.2). This consists of approaching between 200 and 250 customers and running through a survey with each customer every season, which has remained the same the past five years for easy comparison of any changes that may be occurring.



Figure 4.2 A volunteer conducting public education surveys during the 2005 ski season (Photograph by Scott Barnard)

During the 2005 winter season, the blind test of the warning system was recorded by TVNZ and a feature called 'Decade On' on the warning system and response at the ski area was shown on TV one's Close-Up program, followed by a live interview with the Whakapapa ski area manager (Figure 4.3). The 1995 eruption was shown, as well as pictures of the 1995 lahar through the ski area. The blind test was also shown, so viewers were given an idea of what the warning system sounded like and the correct actions to take. The reporter also described that a lahar occurring at Whakapapa ski area was not a case of if, but a matter of when. Science experts indicated that people should not be afraid to come to the mountain as two lahars in 50 years is not a high risk situation, but that it is useful to be prepared. RAL also had a chance to describe for viewers what they are doing to prepare, including their staff induction training and the CIMS course that managers had participated in. This will serve as beneficial public education, as people all over New Zealand were given the chance to learn about lahars at Ruapehu. It also reflects well on the ski area, as they look aware of the situation and are shown taking the proper actions to best prepare.

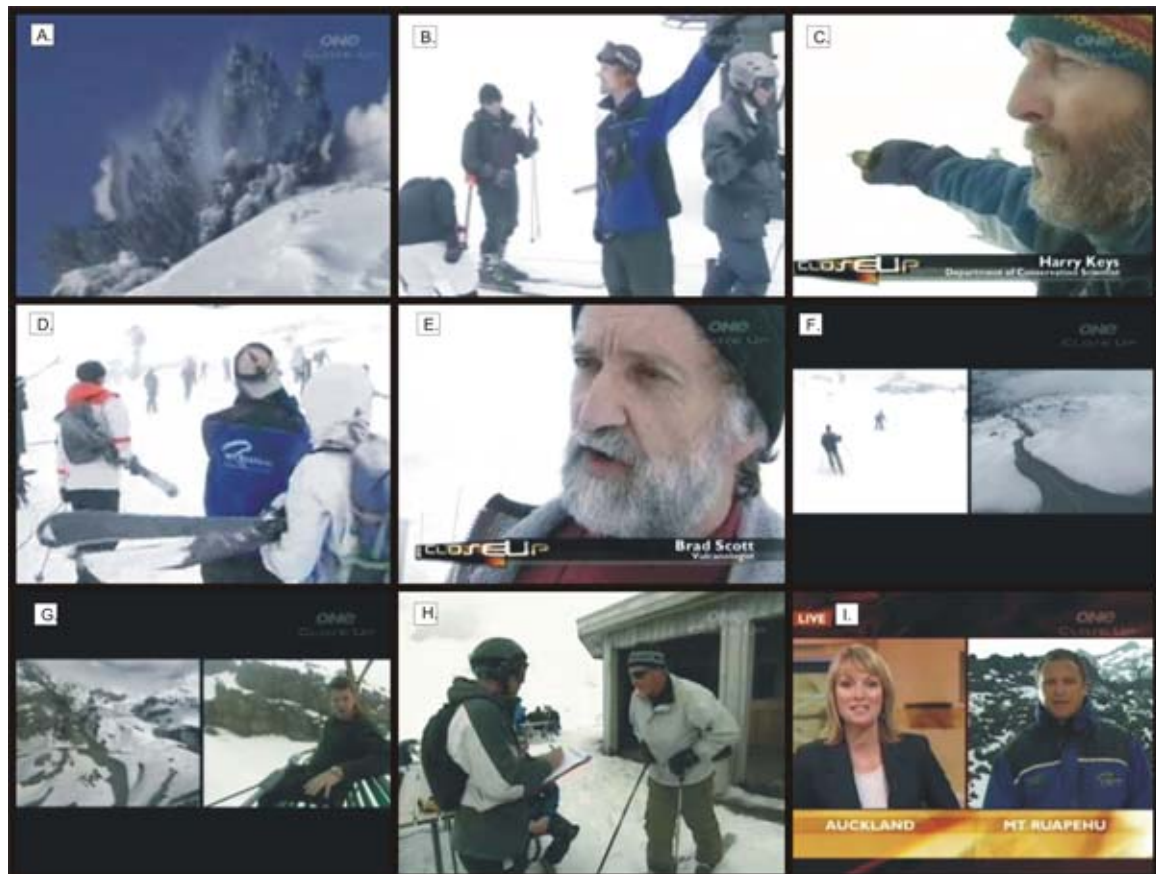


Figure 4.3 Images of the TV one Close-Up program 'Decade On' episode.

A. Image of 1995 eruption at Ruapehu. B. A Lift Operator giving instructions when the warning system has sounded. C. Harry Keys (DoC) showing the proper response actions. D. Skiers moving to higher ground during the lahar warning. E. Brad Scott (GNS) explaining the warning system at the ski area. F. Image of the path a lahar could take and what it would look like. G. Reporter explaining the unpredictability of eruptions at Ruapehu. H. A volunteer doing public hazard awareness surveys at Whakapapa ski area. I. The host of Close-Up interviewing the RAL Whakapapa ski area manager. (TVNZ, 2005)

### 4.3 CIMS and Current response plans

#### 4.3.1 The New Zealand Coordinated Incident Management System (CIMS)

The New Zealand Coordinated Incident Management System (CIMS) (New Zealand Fire Service Commission, 1998) provides a model for the command, control, and coordination of emergency response, focusing on four key components (reduction, readiness, response, recovery). This common incident management structure can be applied to emergency situations. The main principles of CIMS are:

- Common terminology
- Top-down organisational structure
- Integrated communications
- Consolidated Incident Action Plans – preferably written (includes response goals, operational objectives, and support activities)
- Manageable span of control
- Designated incident facilities
- Comprehensive resource management

The CIMS organisational structure has four basic components: control, planning/intelligence, operations, and logistics. The Incident Controller (IC) would be in charge of the response and responsible for coordinating planning/intelligence, operations, and logistics. The position may be transferred as the incident progresses. The structure of a CIMS response and roles within that can be seen in Figure 4.4.

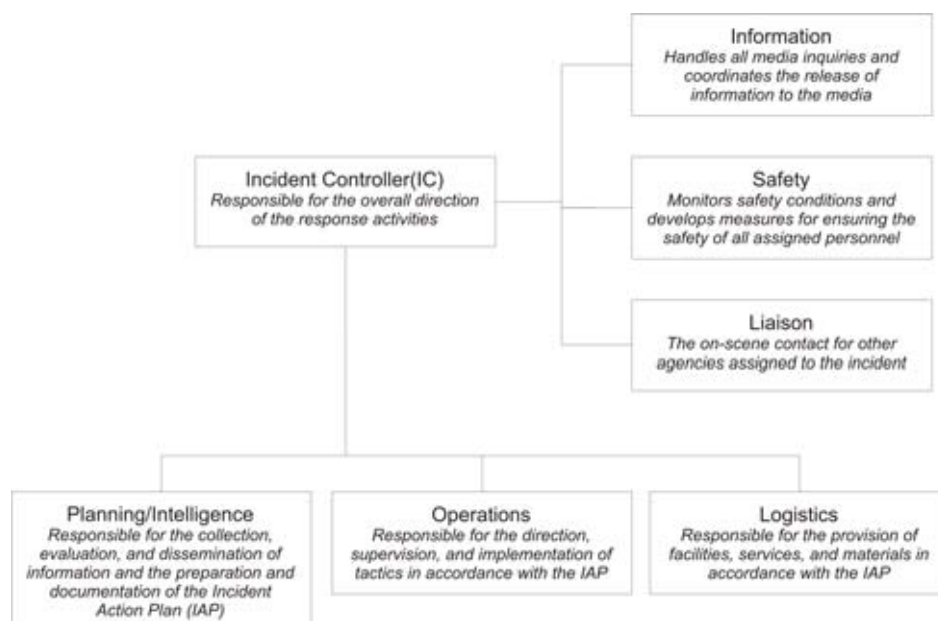


Figure 4.4 CIMS structure

Another important part of CIMS is the identification of incident facilities. The most important facilities relating to an incident on the ski area would be an Incident Control Point (ICP) and Emergency Operations Centre (EOC). The ICP is where the Incident Controller and main incident managers will be located, and there should only be one when multiple agencies are involved. There may be multiple EOCs for an event. It is possible that during a volcanic event at Ruapehu that the ICP would be located in Whakapapa Village and Iwikau Village on the ski area may be an EOC. For further discussion on the application of CIMS to a volcanic event response at the ski area, see Section 7.3.4.

#### 4.3.2 DoC Eruption Response Plan

There are numerous plans that will be used in the response to a volcanic crisis on the ski field. The DoC response plan is titled the 'Ruapehu Eruption Response and Management Plan' (2004) and details the emergency response for Whakapapa Village and the ski area. It is based on CIMS principles. According to the plan, the central Incident Control Point would be in Whakapapa Village, and the Whakapapa Village Controller would be the main Incident Controller. Other controllers would include the Whakapapa Ski Area Controller, the Skotel Controller, and the Lodge Clearing Controller. The Whakapapa Ski Area Controller is designated be the main Incident Controller for the ski area until authority can be shifted to the Whakapapa Village Controller. Figure 4.5 shows the command structure.

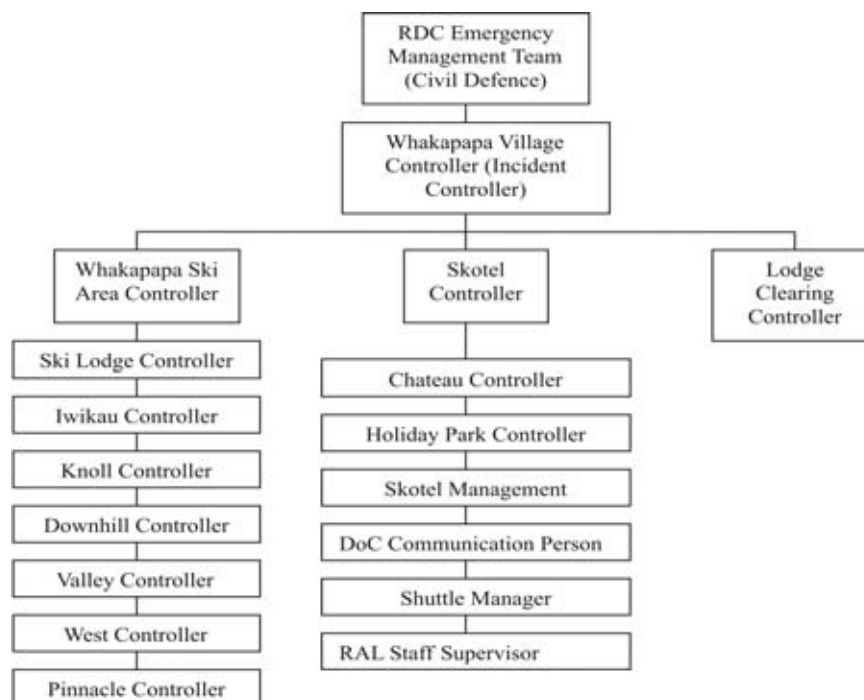


Figure 4.5 DoC Eruption Response Plan Command Structure (Department of Conservation, 2004)



The Action Plan for the Whakapapa Ski Area Controller is also detailed in the DoC Eruption Response Plan. The main tasks for this controller include establishing a Control Point at Iwikau Shelter, appointing a Ski Lodge controller, appointing Sub-area Controllers, and establishing and maintaining communications with the Whakapapa Village Controller. The sub-areas will be as follows:

- Iwikau
- Knoll
- West
- Pinnacle
- Valley
- Downhill

These controllers will be selected from senior management personnel or ski patrol. Situation reports would be requested from all Sub-area controllers, and field teams should be appointed to carry out search and rescue. Treatment centres for injured or sick customers must also be set up. There is no indication in the Eruption Response Plan as to how these centres will be resourced.

The DoC Eruption Response Plan (2004) also details action plans for Lift Operation staff, Ski Patrol, and Ski Club lodges. The Lift Operations staff action plan contains notes on specific actions to take at certain lifts, as well as the general response that should be performed by Lift Operators. Ski Patrollers are also advised on what areas should be highest priority for sweeping. Ski Club lodge leaders are advised to ensure all occupants remain inside, record all persons being shelter and those reported missing, and ensure that roof guttering is isolated from water storage tanks.

The DoC Eruption Response Plan (2004) also contains specific task guidelines for the following areas (many of these specific plans involve direct participation from RAL staff which if noted):

- **Search and Rescue**
  - RAL staff may be requested to participate in ski area search and rescue (likely Ski Patrol staff)
- **Missing Persons**
  - RAL staff may be advised to set up and staff a registration centre (likely Customer Services staff)
- **First Aid/Emergency Care**
  - RAL staff may be required to set-up and staff treatment centres on the ski field (likely Ski Patrol, Medical Centre staff)
- **Electricity**
- **Water supplies**



- RAL staff must disconnect down pipes which feed water storage tanks and must impose water conservation measures (likely Food and Beverage staff)
- **Roads**
- **Shelter**
  - RAL staff may be required to provide sleeping arrangements for customers (likely Food and Beverage, Customer Service staff)
- **Catering**
  - RAL staff will likely be required to cater to persons present at assembly points (likely Food and Beverage staff)
- **Ground Transport**
  - RAL light vehicles and drivers may be needed for ground transport (likely Road Services staff)
- **Traffic Control**
  - RAL staff may be required to place a roadblock at the bottom of the loop road below the workshop, as the road must remain clear for emergency vehicles (likely Road Services staff)
- **Law Enforcement**
- **Disaster Victim Identification**
  - RAL staff may be required to set aside an area for identification and secure storage of deceased persons
- **Communications**
  - The Whakapapa Ski Area controller will communicate with the Incident Controller either by landline, cell phone, RAL UHF radio system, or DoC VHF radio system
- **Aircraft**
- **Road/Bridge Repair**
- **Information Services and Media**

#### *4.3.3 RAL Eruption Response Plan*

Numerous attempts were made by the author to view the RAL eruption response plan, to no avail. It was later discovered during the interview stage of this project that RAL does not have a specific 'plan' to use in the response to a volcanic event; they plan to begin the initial response to the warning system (which is described to all staff members at training), and then apply a broad ski area evacuation plan to the evacuation phase of the response.

## **4.4 Discussion**

The following research questions have been derived from the preceding discussion:

- Have changes to training design influenced staff awareness and response action knowledge?
- Are staff aware on the initial (Stage 1) response actions?

- Are staff aware of the evacuation procedure?
- Can a CIMS structure be applied to a ski area response?
- Are seasonal staff dependent on managers during a volcanic crisis, or are they confident in their knowledge of the response actions?
- Will communication be efficient?
- Are staff versatile enough to respond to a different style of eruption?
- Do the DoC and RAL Eruption Response Plans have similar goals?
- Are staff knowledgeable of past eruptions and the impacts on the ski area?
- What do staff expect to happen during a volcanic event? Do they have realistic expectations? Are they educated on physical stressors, but also told what to expect mentally?
- IS RAL aware of the increasing risk from a volcanic event on their ski areas, as skier numbers and facilities increase, and the difficulty this may add to the response and evacuation?
- How can risk at the ski areas best be managed to include maximum economic vitality?



Figure 4.6 De-icing crew at Whakapapa, 2005 winter season



## Chapter Five

# Methodology

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In this chapter, the methodology of this research project is discussed. Participants of the study and ethical issues relating to the study are presented. The four main data collection methods are also explained in detail, and topics of the staff interviews and surveys are also discussed. The Grounded Theory Method is then introduced and explained, including the selection of themes. The analysis methods applied to the four types of data are also brought up. The reliability and validity of the data and analysis is explained.

## 5. METHODOLOGY

### 5.1 Participants

Participants for this study were staff working for Ruapehu Alpine Lifts during the 2005 winter season. Both permanent and seasonal staff were included. Staff were randomly selected from all ski field departments:

- Permanent staff/ Management,
- Ski Patrol/ Trail Safety,
- Lift Operators,
- Snow School,
- Customer Services,
- Food and Beverage,
- Rental/Workshop/Retail,
- Groomers, and
- Road Services.

Staff were invited to participate in the study by a request from the interviewer. Participation was voluntary, however all staff approached to be involved in the study decided to participate. An information sheet was then provided to participants of the semi-structured interviews (Appendix 2).

## **5.2 Ethical Issues**

Details about this research project were sent to the University of Canterbury Human Ethics Committee for review and approval. Participants also signed consent forms, agreeing that their participation in the research was not anonymous but would be confidential.

## **5.3 Data Collection**

### *5.3.1 Staff Training Observation*

Staff induction week took place from June 13<sup>th</sup> to 16<sup>th</sup> at Turoa ski area, and from June 20<sup>th</sup> to 23<sup>rd</sup> at Whakapapa ski area. The general company induction was observed by the author for both ski areas. Health and safety training sessions were observed for Lift Operations, Customer Services, Food and Beverage, Rental, and Road Services staff at Turoa ski area. At Whakapapa ski area, health and safety training sessions were observed for Food and Beverage, Lift Operations, Snow School, and Groomer staff.

### *5.3.2 Staff interviews*

Staff interviews were conducted at Whakapapa ski area by the author; 13 permanent staff were interviewed from June 8<sup>th</sup> to the 10<sup>th</sup>, before staff induction week, and 13 seasonal staff were interviewed from July 29<sup>th</sup> to August 1<sup>st</sup>. Seasonal staff interviews occurred a month after staff induction week, but before the lahar warning system simulation. The interviews were semi-structured, as a guideline of interview questions was prepared but participants were allowed to guide the interviews to a point. Participants were questioned to saturation, which is the point where participants could add nothing further to the question. Interviews ranged in length from 16 minutes to 69 minutes. The interview lengths were dependent on the length of time the participant had worked at the ski area, as well as their knowledge of volcanic hazards and RAL's response plans. All interviews were audio-taped.

The following basic topics were covered in the interviews:

- Background information, including daily roles at the ski area,
- 1995/96 eruptions,
- Staff induction week,
- Volcanic Hazards at Ruapehu,
- Lahars,
- Warning system at the ski area,
- Response to a volcanic event
  - Any assumptions the company is making
  - Problems that may arise
  - Stressful issues for staff
  - Their specific role in the response effort
  - Suggestions for improving the response, and
- Public education at the ski areas for volcanic hazards.

### *5.3.3 Staff surveys*

Surveys were prepared by the research team, and distributed by RAL Human Resources staff at both Whakapapa and Turoa ski areas. In total, 225 surveys were given out; 150 at Whakapapa and 75 at Turoa. 70 surveys were returned by Whakapapa staff, which represents a response rate of 47%, and 19 by Turoa staff, which represents a response rate of 25%. The total response rate was 40%. The distribution of departments and years worked by survey respondents can be seen in Figures 5.1 and 5.2 respectively. Survey questions were open-ended to ensure that bias in responses were minimized as far as possible. The survey can be found in Appendix 2.

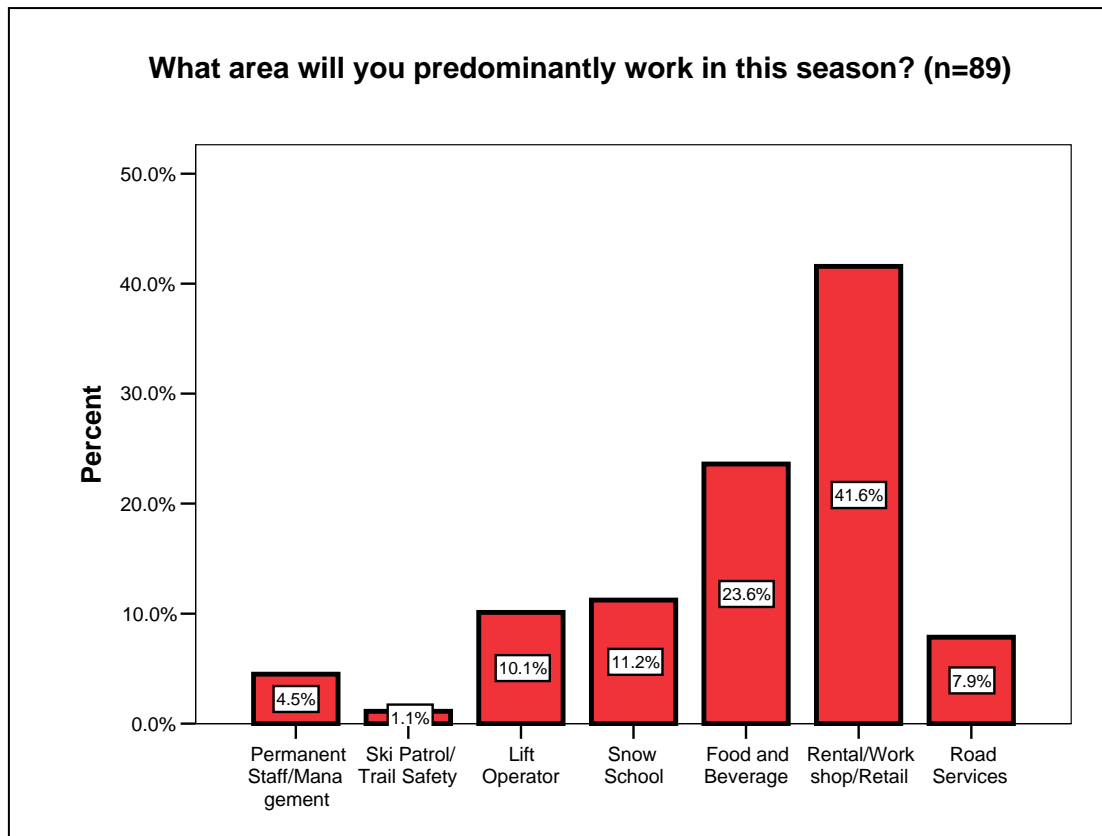


Figure 5.1 Departments worked by survey respondents.

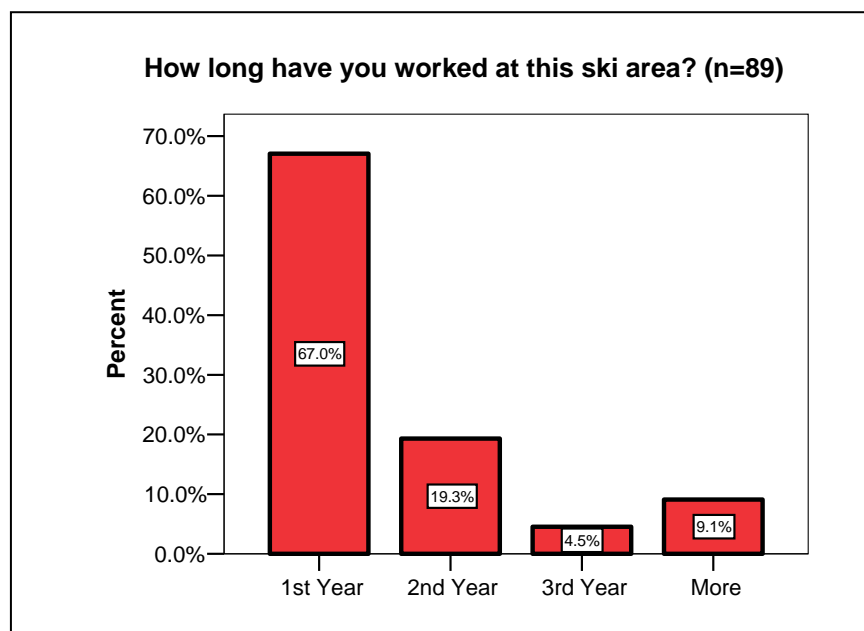


Figure 5.2 Length of experience at ski area

#### 5.3.4 Observation of simulation and blind test

Two tests of the warning system were held during the 2005 winter season. The first was held on August 3<sup>rd</sup> and was a simulation exercise for ski area staff. All staff were notified of the test ahead of time and reminded of the correct actions to take. Observers from GNS, DoC, and RAL (including the author) were placed in strategic positions around the ski area (Figure 5.3) and took observations of the alarm audibility, customer response, and staff response to the warning system.

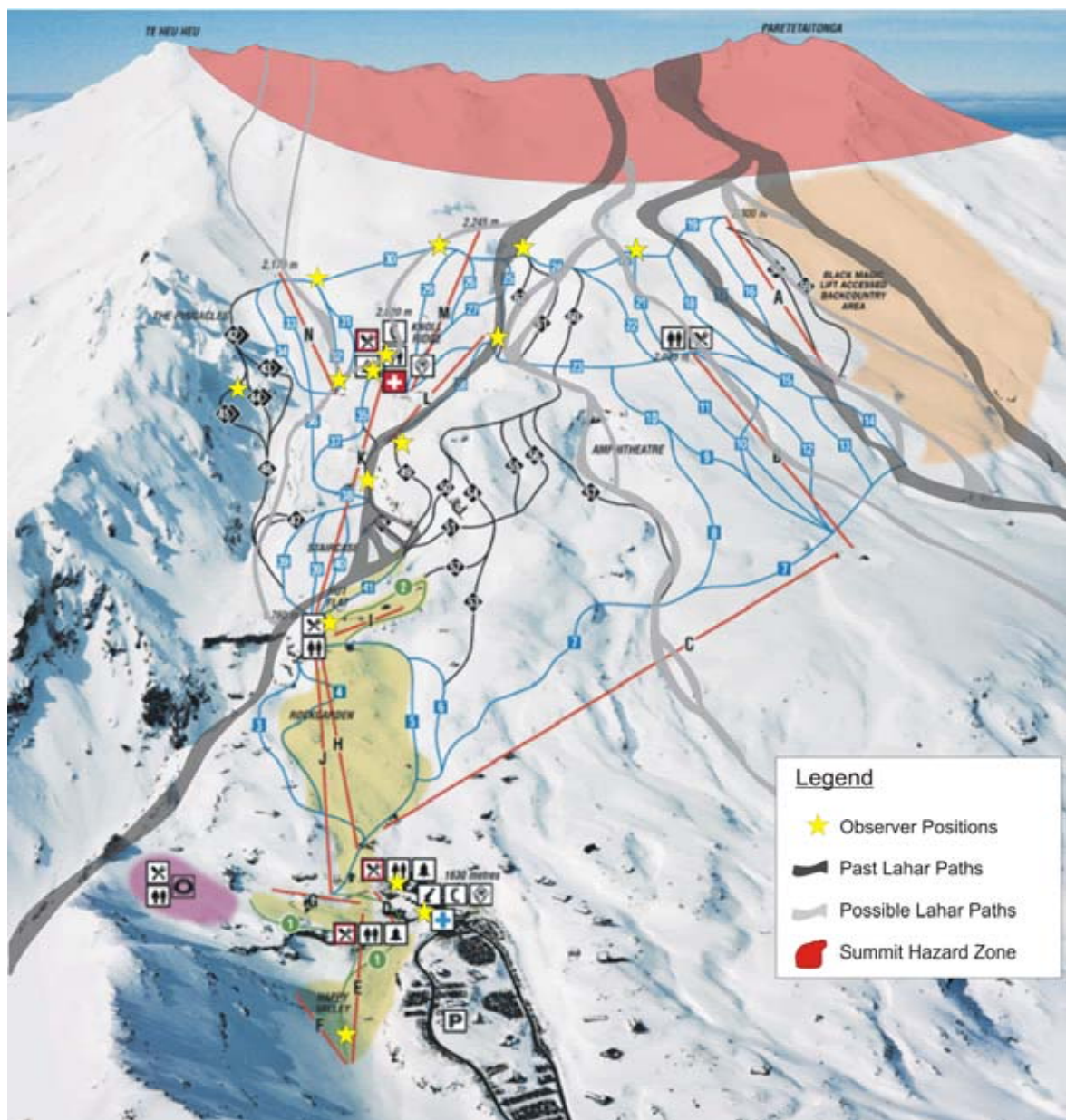


Figure 5.3 Observer locations for simulation exercise



A second test of the warning system was held on October 12<sup>th</sup> and was designed to be a blind test, where staff would be unaware of an impending alarm. However, due to unusual activity, particularly the presence of a camera crew filming the test, many staff were suspicious. The Ski Patrol radio channel was also observed during this test. Observers from GNS, DoC, and RAL (including the author) were placed in strategic positions around the ski area again (Figure 5.4) and took observations of the alarm audibility, customer response, and staff response to the alarm.

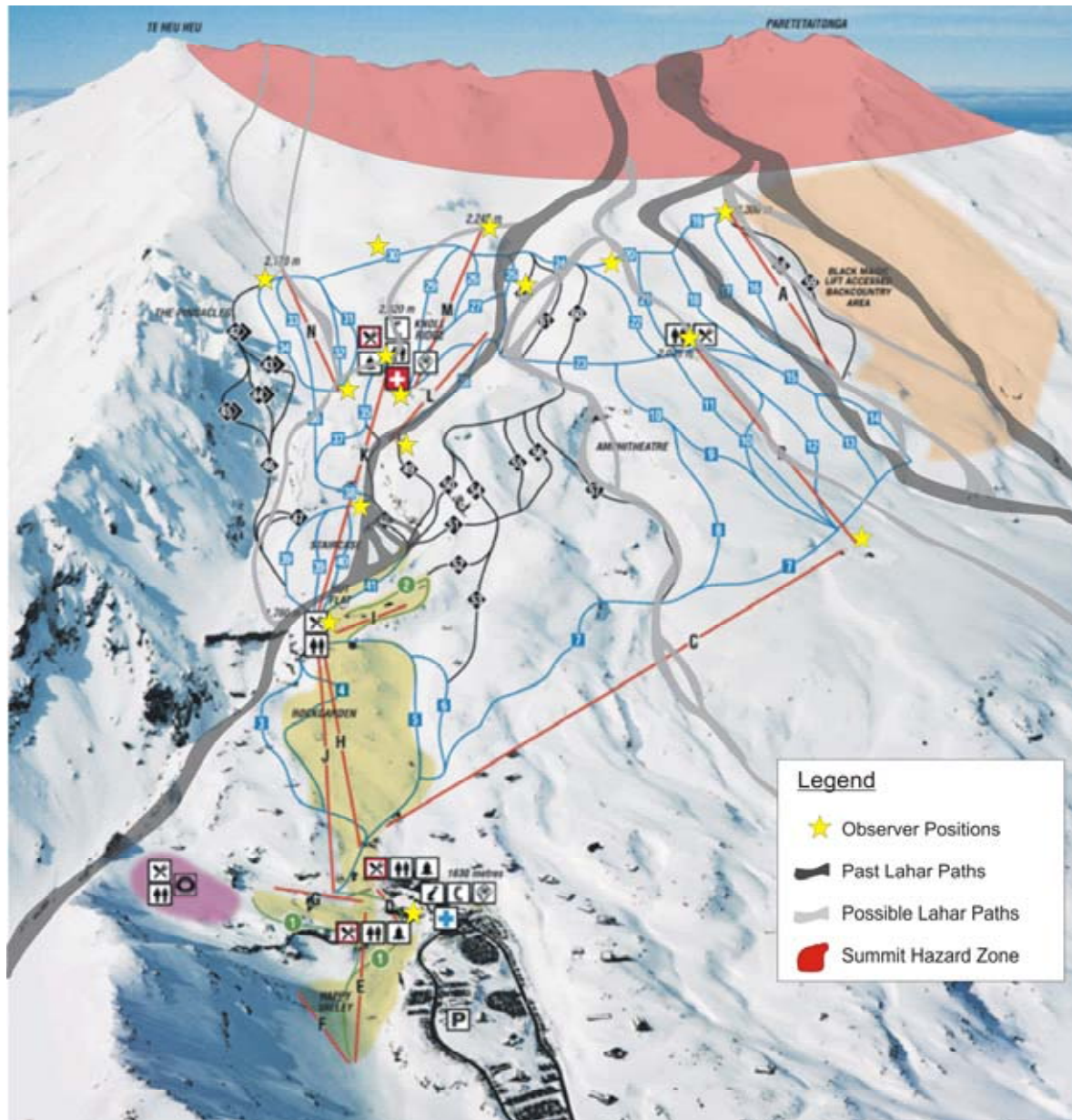


Figure 5.4 Observer locations for blind test



## 5.4 Data Analysis

### 5.4.1 The Grounded Theory Method

Grounded theory was developed in the late 1960s by Glaser and Strauss (1967) as a method of qualitative research which would allow theory to be generated systematically from the data. Therefore, in classic grounded theory, data is collected, coded, and conceptualized simultaneously throughout the project (Lacey and Luff, 2001). Generally, the strongest cases for use of grounded theory is when researching exploratory studies (Lacey and Luff, 2001) or to gain a new perspective in a familiar situation (Stern, 1994). Charmaz (1994) defines grounded theory research as:

*“Grounded theorists affirm, check, and refine their developing ideas, but they do not limit themselves to preconceived hypotheses...the groundedness of this approach fundamentally results from these researchers’ commitment to analyze what they actually observe in the field or in their data”.* (p. 68)

Grounded theory often begins with a clear, but broad, research question, rather than a tightly framed hypothesis (Charmaz, 1994). The researcher then begins collecting the data, constantly looking for relationships by comparing categories to form the base of the emerging theory (Lacey and Luff, 2001). This process continues until theoretical saturation is reached, which is where no new significant categories are emerging from the data (Lacey and Luff, 2001). It is possible that during the research, new ideas will emerge which may lead the researcher in unanticipated directions (Charmaz, 1994).

Themes can then begin to be developed from this data, as codes pull together discrete statements, events, and observations. At first, the data can appear confusing and unrelated, however by coding order will begin to be created (Charmaz, 1983). According to Holsti (1969) themes that begin to be developed should:

- (i) reflect the purposes of the research,
- (ii) be exhaustive,
- (iii) be mutually exclusive,
- (iv) be independent, and
- (v) be derived from a single classification principle.

For themes to be exhaustive, all relevant items in the data analysis must be capable of being placed into a category. Categories must be constructed by trial and error methods, which consists of “moving back and forth from theory to data, testing the usefulness of tentative categories, then modifying them in light of the data” (Holsti, 1969, p. 104).

There are many different units of analyses that can be used. For this research, themes will be used. A theme is generated when similar issues and ideas are brought together by a researcher into single categories. Themes can either be labelled by a word or description directly from the data, or one created by the researcher to best describe what is being said (Lacey and Luff, 2001). It is the most useful unit of content analysis because it is indispensable in research on propaganda, values, attitudes, beliefs, and the like. However, the main drawback of using themes is that boundaries are not easily identifiable (Holsti, 1969). It is also important to make themes fit the data, rather than forcing the data to fit into the themes (Charmaz, 1983). Themes may then be sub-divided into sub-categories, which will help to build and clarify a theme (Charmaz, 1983). However, developing these sub-categories will increase as the researcher will have to make finer and finer judgements: it is also imperative that sub-categories do not become so narrow that the sub-categories become virtually identical with the raw data (Holsti, 1969). The themes and sub-categories for this study can be found in Appendix 6.

There have been recent criticisms of grounded theory, particularly of not using literature to develop the categories. However, Charmaz (1994) argues that when using grounded theory the literature review is only delayed, not overlooked, and this delay decreases the likelihood that the researcher will become led by preconceived conceptual blinders when interpreting the data.

#### *5.4.2 Staff Training Observation Data Analysis*

The staff training observations were typed and separated into ski area, and then departmentally. The training induction week observations were summarized, as was the Health and Safety Session, into the main ideas. Common themes and important points from the lahar safety sessions were extracted from the observations.

#### *5.4.3 Interview Data Analysis*

Following the interviews at Whakapapa ski area, audio-tapes were converted to digital files and then transcribed by the author, which was useful for gaining initial familiarity with the data. Non-verbal cues were also recorded in the transcript, as they are important elements of a conversation and may give added insight into the spoken word (Lacey and Luff, 2001). Interviewing is a way to come to understand the beliefs, attitudes, and expectations of the other person, and begin to understand the cognitive models that shape their worldviews (Krippendorff, 2004). Mental models can be elicited and evaluated by using open-ended interviews which allow the participants to

describe complex processes in as much detail as possible (Spedden, 1998), such as a ski area evacuation. Familiarisation with the data then continued, by re-listening to the audio-tapes and re-reading the transcripts and making general notes.

The interview transcripts were then open-coded for main themes, by colour coding and sorting key phrases in the text. Although this does not seem scientific, it is one of the best ways to begin hunting for patterns (Ryan and Bernard, 2005). According to Seidel (1998), this initial sorting has three effects:

1. It leads to revisions in your coding scheme
2. It helps you notice new things in your data
3. It facilitates the process of thinking and making discoveries.

Recurring themes were then noted and looked for in other interviews. Triangulation was used to identify any relationships between themes. The list of themes and sub-categories can be seen in Appendix 6. Important quotes that illustrated the main ideas were then extracted from the text.

#### *5.4.4 Survey Data Analysis*

Surveys were collected by Human Resources at Whakapapa and Turoa ski areas, and mailed to the author. The data was then entered into SPSS 13.0, and analyzed. The complete results can be seen in Appendix 3. Similarities between the interview data and the survey data were looked for and noted.

#### *5.4.5 Simulation and Blind Test Observation Data Analysis*

Observation sheets were collected from the observers following the simulation and blind test. These were typed up, and the observations were split into specific areas so the author could begin to get an idea for how each department and each part of the ski area responded. This then gave an overall idea for how each department remembered and responded to the training they had received. The complete results can be seen in Appendices 4 and 5.

### 5.5 Reliability and Validity

According to Krippendorff (2004), for data to be reliable, it must:

1. have been generated with all conceivable precautions in place against known pollutants, distortions, and biases, intentional or accidental, and
2. mean the same thing for everyone who uses them.

Therefore, the most important form of reliability is replicability (Krippendorff, 2004). In qualitative data analysis, it is important for the researcher to demonstrate that the methods that have been used are reproducible and consistent (Lacey and Luff, 2001). Reliability is a “function of the coder’s skill, insight, and experience, clarity of categories and coding rules which guide their use; and the degree of ambiguity in the data” (Holsti, 1969). Categories must be defined to accurately measure the ideas the researcher is trying to measure. This can in part be accomplished by developing rules that allow multiple coders to categorize and code the data in the same way over a period of time (Writing Center at Colorado State University, 2005). This is referred to as stability.

Inter-rater reliability was used to provide a check on the consistency and transparency of the analysis (Lacey and Luff, 2001). Data analysis for this study was undertaken by two separate researchers. Both researchers initially coded the interviews, then compared themes and sub-categories to ensure reproducibility. There were very few inconsistencies in this initial coding process between researchers.

It is also important that research yields valid results, as the research effort should be open for careful scrutiny and the interpretation can be upheld in the face of other evidence (Krippendorff, 2004). In other words, “validity will be judged by the extent to which an account seems to fairly and accurately represent the data collected’ (Lacey and Luff, 2001). However, validity cannot be ascertained through duplications, as reliability does not guarantee validity. For example, although two researchers may agree on their interpretation, they may have similar worldviews that differ from the worldviews of those whose beliefs, actions, and intentions are at issue (Krippendorff, 2004).

Triangulation is often used to demonstrate rigour of the research. Triangulation means that data is gathered and analyzed from more than one source to give the researcher a fuller perspective on the study (Lacey and Luff, 2001). In this research project, various data sources were analyzed, such as semi-structured interviews, survey responses, observation of warning system tests, and observation of staff training. Contradictions and differences between the different data sources was used to spur the researcher on to further investigation to make sense of what was happening (Lacey and Luff, 2001).



## Chapter Six

# Results and Initial Discussion

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Results from the research are presented here. The first section looks at the results from the analysis of the staff training observation for the 2005 winter season. The complete observations can be found in Appendix 1. Staff survey results are then discussed in multiple subsections relating to the main topic of each area of the survey. The full survey results can be found in Appendix 3. The staff interview results are also detailed, and are also split into subsections of the main themes that were brought up by staff members. The results from the observations of the simulation are also summarized, with the complete observations listed in Appendices 4 and 5.

## 6. RESULTS

### 6.1 Staff Training for the 2005 winter season

Opening days for Turoa and Whakapapa ski areas were June 17<sup>th</sup> and June 24<sup>th</sup> respectively for the 2005 ski season. Staff induction week took place from June 13<sup>th</sup> to 16<sup>th</sup> at Turoa ski area, and from June 20<sup>th</sup> to 23<sup>rd</sup> at Whakapapa ski area. Training at both ski areas had fairly similar set-ups; however the content discussed was slightly different. Both staff induction weeks began with a general company induction for new staff, which lasted 4 hours. The RAL general manager spoke about the history and future of the company at each session, including the 1995/1996 eruption and its effects on the ski areas. Also mentioned were major activities for the ski areas for 2005, as well as company values and policy. New staff were then introduced to department managers. After this general session, staff were split into their departments to attend department-specific training sessions for the rest of the week.

In the past, RAL has provided all staff with one health and safety training session that all new staff were required to attend. Coverage of the volcanic hazard safety training lasted approximately 20 minutes, the majority of which included watching the RAL/DoC lahar hazard safety video. In the video, the past Safety Services manager covered volcanic hazards and the Eruption Detection System (EDS), and briefly described past damage on the ski area from lahars. The correct response actions were also explained for different areas of the ski area, however these actions were heavily biased towards the likely response actions of Lift Operators and Ski Patrol, leaving many departments uncovered.

The 2005 winter season was the first year RAL implemented some of the training recommendations from Ward et al. (2003), by separating each department for separate health and safety training sessions, which included the lahar hazard training and also by asking returning staff to attend. The Safety Services department at each ski area led the Health and Safety training session covering volcanic hazards, mountain environmental hazards, avalanche awareness, fire safety and detection, the snow responsibility code, RAL health and safety system, and department safety, in approximately two hours. The largest portion of time was spent on the mountain environmental hazards and avalanche awareness. At the beginning of the training, staff were given a test to fill in during the presentation to be submitted later. The following sections will cover the observations from only the volcanic hazard section of the Health and Safety training.

### *6.1.1 General Structure of Volcanic Hazard Training*

The volcanic hazard training sessions at Whakapapa and Turoa were both given using the same power-point presentation. The sessions at Turoa lasted for 10 minutes on average, followed by the RAL/DoC lahar hazard video. The sessions at Whakapapa were run more as a workshop and averaged 30 minutes, also followed by the RAL/DoC lahar hazard video. The beginning of the session focused on introducing the staff to the warning system at Whakapapa ski area, and the pager system at Turoa linking them to that warning system. The 1995/95 eruptions were also introduced, with a brief description of the eruption. Staff were then shown the public education poster and brochures, and told about the lahar paths and summit hazard zone. They then were given a brief description of what will happen when the warning system is triggered. The next part of the session was specific to each department, with each department being described the specific response actions they will need to take. The video was then played, however in about half of the sessions that were observed the tape failed to work, having either sound problems or cutting out after about five minutes.

The following section briefly summarizes the department specific training observed at each ski area. A complete summary of observations can be found in Appendix 1.

### *6.1.2 Summary of Department-specific training*

#### Turoa

It was mentioned in all the lahar hazard training sessions at Turoa that the main hazard at the ski area was from ballistic bombs. The feeling that Turoa was at much lower risk than Whakapapa was also told to staff, and the overall feeling about a potential eruption was positive, with it being described as ‘cool’ and ‘awesome’. The session leader also went into detail about his experience during the 1995/96 eruptions, which staff were interested in. All the departments received specific instructions about their role in the response to a volcanic eruption, with Lift Operations receiving the most detailed instructions. Staff in all sessions were found to be concerned that Turoa did not have a warning system, as well as whether there would be any warning signs before an eruption. Some groups of staff, particularly Road Crew and Customer Service, thought they would not have to worry because they likely would not be on the mountain; however the session leader stressed that they could be on the mountain skiing when an eruption occurred, so it was also important to know for personal safety.

#### Whakapapa

At Whakapapa, emphasis was laid on informing staff about the lahar hazard on the ski area. Most departments were informed that the likely warning time between when the warning system sounds and when a lahar may enter the ski area to be three minutes. However, this is likely an over-estimation, as the warning time is expected to be closer to 90 seconds. All departments were given specific instructions as to their response, with Lift Operations receiving the most detailed instructions. The higher risk in the Far West area was also brought up with Snow School staff. Staff at Whakapapa were far more concerned over certain issues than Turoa staff, such as:

- Whether the mountain would have warning signs before an eruption,
- Whether people on the ski area had died during past eruptions,
- Customers panicking,
- The evacuation plan,
- Communications during the event, and
- The Crater Lake Tephra Barrier collapse.

It was also emphasized to staff that there would be practice alarms at the ski area, as well as potential false alarms, but that it was important to treat each alarm as real.

## **6.2 Staff Surveys**

### *6.2.1 General*

The following results are from the 2005 winter season staff survey from Whakapapa and Turoa ski areas. Refer to Appendix 3 for the complete survey results. 150 surveys were handed out to Whakapapa staff, and 75 were handed out to Turoa staff encompassing all ski area departments. 79% of the returned surveys were from Whakapapa and 21% were from Turoa. The significant difference in response rates may possibly point to several factors, such as seasonal staff at Turoa not being as concerned about volcanic hazard as seasonal staff at Whakapapa or management staff at Turoa not being as keen to get surveys out to their staff and have them completed as management staff at Whakapapa. This likely results from the traditional feeling that Whakapapa ski area is at much higher risk from volcanic hazards than Turoa.

The majority of staff respondents were from the Rental/Workshop/Retail departments (42%), followed by Food and Beverage staff (24%), Snow School staff (11%), Lift Operations staff (10%), Road Services staff (8%), management staff (5%) and Ski Patrol/Trail Safety staff (1%) (Figure 5.1). Although surveys were handed out randomly to each department, none were received at either ski area from the Customer Service department or the Snow Grooming department, and only one survey was received from Ski Patrol/Trail Safety staff. The majority of respondents were first year staff (67%), followed by second year staff (19%), four or more year staff (9%), and third year staff (5%) (Figure 5.2).

### *6.2.2 Lahar Knowledge*

Staff respondents were first asked to identify what they thought a lahar was. The majority of respondents said volcanic mudflow (49%), which is the definition presented to staff in seasonal training as well as the definition on public education posters located around the ski areas. Other responses included can be seen in Figure 6.1.



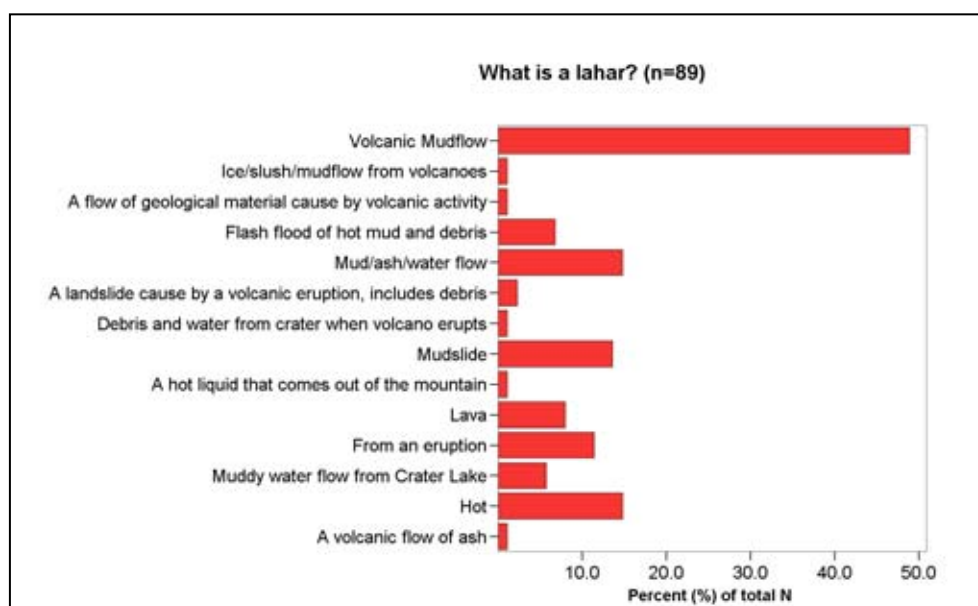


Figure 6.1

The majority of responses are similar to a volcanic mudflow, however the responses ‘hot’ and ‘lava’ are incorrect. The confusion with a lahar being hot is relatively easy to explain, as it is relatively unknown that lahars at Ruapehu are known as cold lahars, which are near supercritical temperature when they are flowing and freeze almost instantly when they stop moving (Manville, 2005). A lahar is not flowing lava either, although this misconception may also be easy to explain. Rodolfo (1995) experienced a similar misconception during the 1991 Pinatubo eruption, and accounts it to the following:

*“In a way, it is a pity that the lavas of Hawaii are so spectacularly photogenic, because images of flowing fountains and streams of lava dominate most television and film footage of eruptions and leave us with the impression that flowing lava is the principal volcanic product and hazard.” (p. 97)*

Therefore, it is possible that ski area staff at Ruapehu are applying this same recognition of Hawaiian volcanoes to an eruption at Ruapehu. Another note of interest is that 73% of staff respondents referred in their definition to either an eruption or volcanic activity occurring alongside a lahar or causing a lahar to form. This is largely correct for a lahar that would affect the ski areas, although lahars may also form by collapse of a crater lake (see Section 2.3) or as a secondary event.

Respondents were then asked how a lahar was likely to act (Figure 6.2). The majority of respondents indicated that a lahar ‘runs downhill, usually in the valleys’ (23%). The other common responses included ‘fast moving’ (17%), ‘flows like a river’ (14%), ‘flows down the mountain’ (11%), and ‘like a flash flood’ (10%).

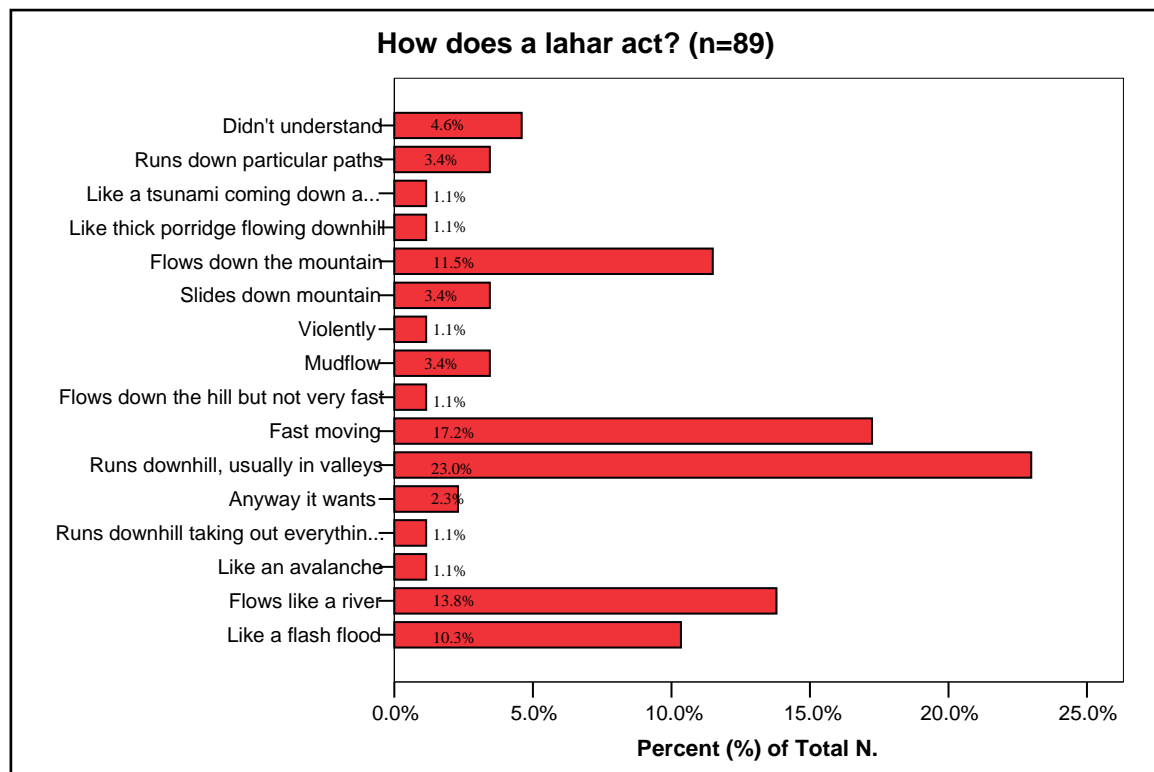


Figure 6.2

All responses were fairly consistent with the typical behaviour of a lahar, which is running downhill in valleys at a fast speed. The respondents who answered a lahar is 'not very fast' and moves 'like thick porridge' are of concern, as they likely do not understand the speed with which a lahar is likely to be moving through the ski area. Fortunately, this was a very small percentage of responses.

Staff respondents were then asked how much warning time they believed there would be between an eruption (or the alarm triggering) and a lahar entering the ski area (Figure 6.3). Responses were grouped into seven categories:

- Not much warning time (23%)
- 2 to 5 minutes (16%)
- 5 minutes (18%)
- 5 to 10 minutes (7%)
- 10 minutes (11%)
- 10 minutes to an hour (10%)
- Over an hour (1%)

It was indicated by 5% of respondents that they were unsure of the warning time.



Figure 6.3

The majority of respondent (56%) felt there would be a short amount of time to respond, at least 5 minutes or less. Of particular concern are the 23% of staff respondent who believe they would have over 10 minutes, and up to and over an hour, to respond before the lahar is a threat to the ski area. However, the 1995 lahars entered the ski area 90 seconds after the initial eruption (Nairn et al., 1996) and it is likely the warning time for a future event may be similar. It is likely that these staff are unaware of the 1995 lahars and the speed to which they moved. If staff assume a longer warning time, the less likely they are to develop a capability to respond immediately, increasing the risk in the event of a suddenly-occurring, fast onset event.

The next survey question asked respondents about the potential hazards from a lahar (Figure 6.4). A majority of respondents indicated 'death' (55%) and 'injury' (21%). Following 'death' and 'injury', the next highest responses were 'being swept away by a lahar' (19%), 'damage to buildings' (19%), and 'damage to lifts' (19%).

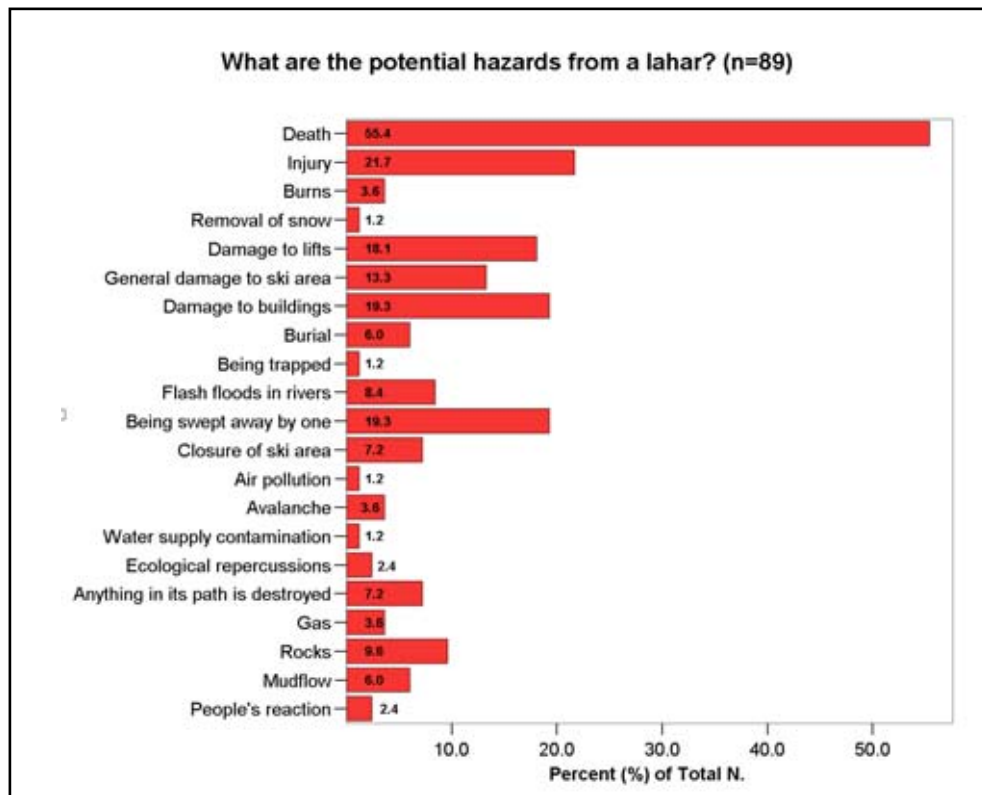


Figure 6.4

These responses were quite different than what was expected by the author. There was a slight misinterpretation of the question, as the term ‘hazards’ was meant to insinuate possible sources of danger to a person caused by a lahar, which could result in ‘death’ or ‘injury’. Examples of this include getting swept away or being hit by rocks. Therefore, ‘death’ and ‘injury’ were not expected responses, however the overwhelming number of recipients who indicated ‘death’ or ‘injury’ from a lahar shows it is of major concern to them. Respondents also seemed very concerned about damage to ski area infrastructure (51%).

### 6.2.3 Lahar Training

The next question asked respondents if they thought lahar training was important. The response was overwhelmingly positive, as 97% of staff indicated they thought it was important, while only 2% thought lahar training was not important.

Respondents were then asked why they thought lahar training was important (Figure 6.5). The majority of responses were ‘to prevent accidents and fatalities on the ski area’ (44%), as well as ‘to learn the correct response actions’ (43%) and ‘to increase awareness’ of the volcanic hazards at Ruapehu (38%). Other responses included:

- ‘Because the volcano could erupt at any time’ (17%)
- ‘Because there are going to be lots of panicked people’ (2%)
- ‘We are responsible for the wellbeing and safety of our customers’ (1%)

3% of responses were negative, as those respondents thought lahar training was not important because they ‘don’t live near volcanoes’ (1%) and because they are ‘working in a safe zone’ at the ski area (2%).

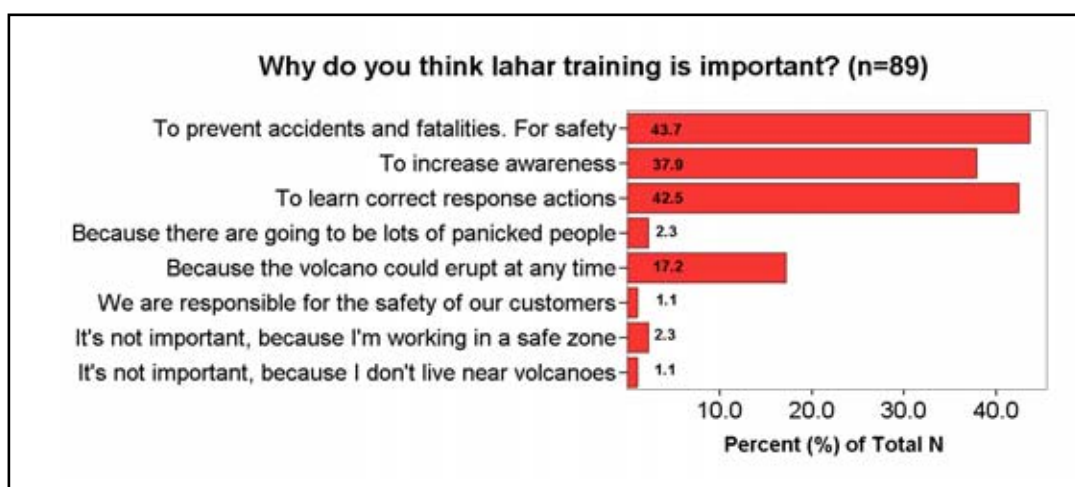


Figure 6.5

An interesting dilemma on the ski area is that many staff work in ‘safe’ areas, which was reported by respondents in this survey for why lahar training was unimportant (2%). This is a valid feeling for staff to have, however staff in safe areas will have just as important role during a volcanic event as those out on the ski area, as they will be required to keep customers calm and in the safe areas. Therefore, it is an important point for senior staff at the ski area to stress to seasonal staff.

#### 6.2.4 Likelihood of a volcanic event

The next question asked respondents when they think the next volcanic event is likely to affect the ski area and were given the choices of ‘within the next year’, ‘within the next ten years’, ‘within your lifetime’, ‘not within your lifetime’, and ‘don’t know’ (Figure 6.6). The majority of respondents chose ‘within the next 10 years’ (38%). A surprising number of respondent chose ‘within the next year’ (28%), followed by ‘within your lifetime’ (17%). No respondents chose ‘not within your lifetime’, and 16% of respondents were unsure of when the next volcanic event was likely.

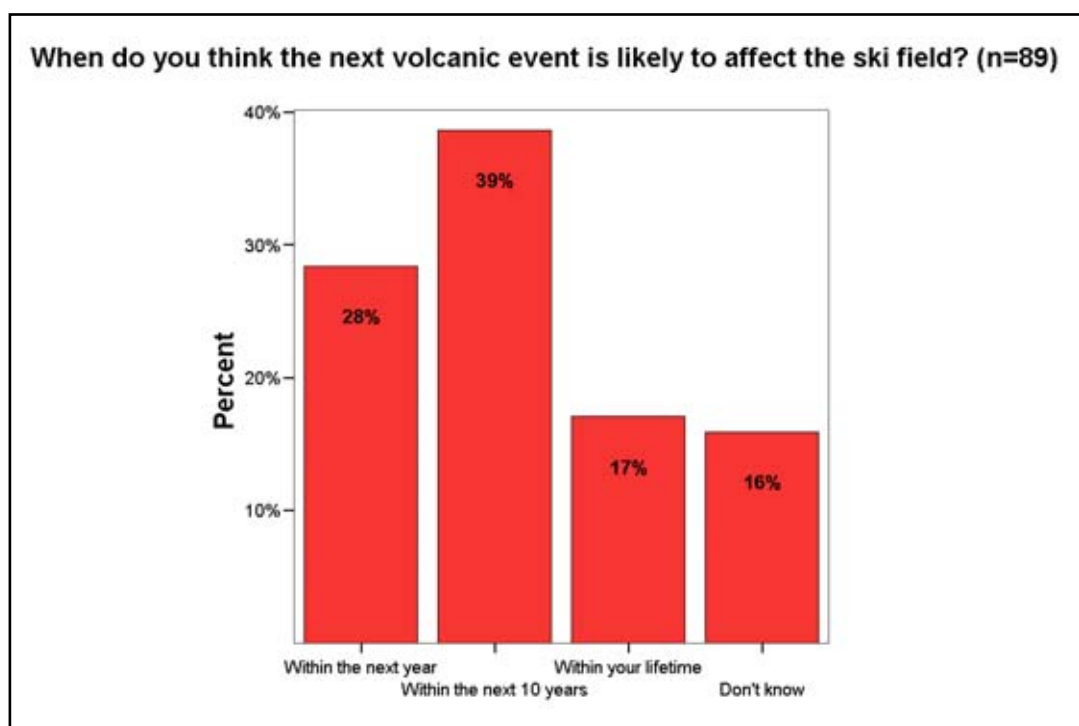


Figure 6.6

Some of the surprising number of respondents for ‘within the next year’ (28%) can likely be attributed to the increase in media coverage of the Crater Lake barrier failure (see Section 2.3). Media have reported that the Crater Lake barrier may fail within the next year (The New Zealand Herald, 2005a and 2005b), which many staff may have recalled to influence their response for this question. This demonstrates the importance for lahar training at the ski areas to focus on explaining the difference between a Crater Lake barrier failure lahar and an eruption-caused lahar, as only the latter has the potential to affect the ski area.

### 6.2.5 Warning System Knowledge

The next survey question asked staff what the components of the warning system at their ski area are (Figure 6.7). Because of the different style of warning systems at both ski areas, responses were split into Whakapapa and Turoa staff. 80% of staff at Whakapapa ski area were aware that the warning system at their ski area consisted of ‘siren and speakers’, with some respondents indicating an ‘announcement’ would also be played (35%). Some staff displayed knowledge that the volcano was being monitored (24%), with 21% of all respondents specifically referring to the ‘EDS’.

The majority of staff at Turoa ski area knew the volcano was being monitored in some way (58%), and 26.3% of all respondent specifically referred to the ‘EDS’. Of concern are the 32% of staff who indicated that the warning system at Turoa comprised ‘sirens and speakers’, which is not true. It is likely these staff are confused with the warning system at Whakapapa ski area.

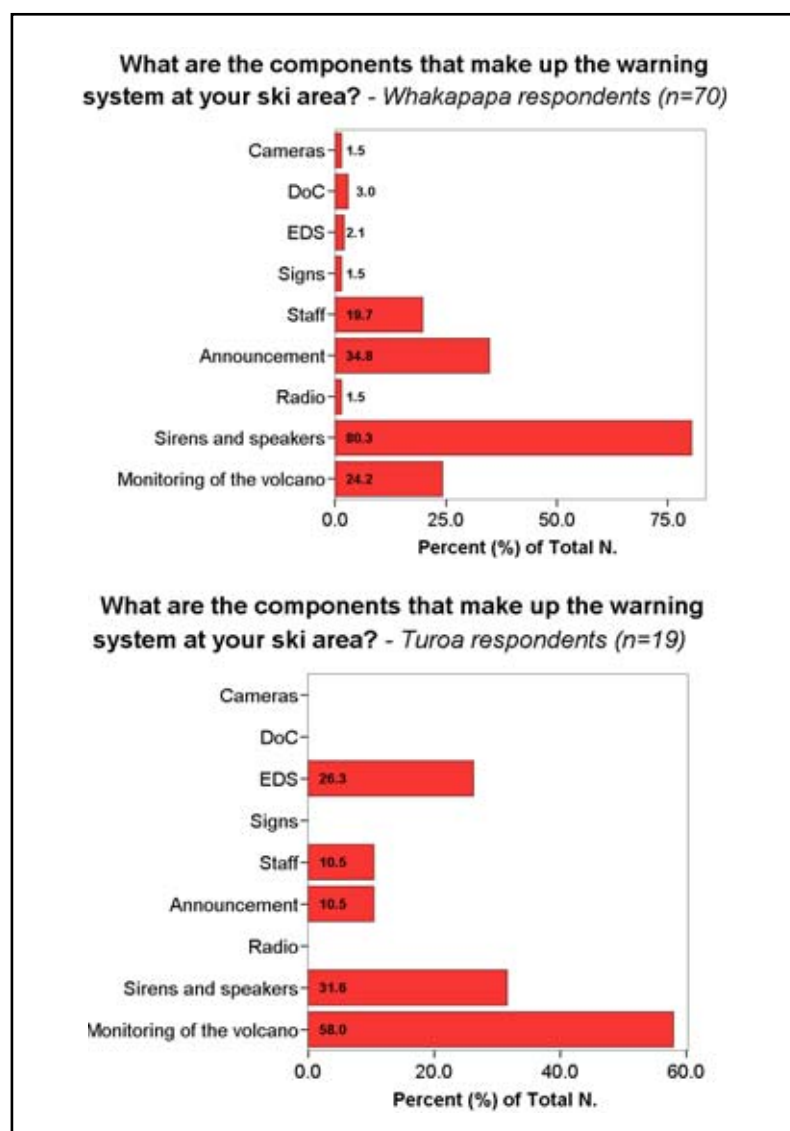


Figure 6.7

Also of concern is that none of the Turoa staff noted that the warning system used notification by 'radio', which is how management staff at Turoa plan to get the word out to staff on the ski area that the EDS has been activated. However, 11% of respondents indicated there would be an 'announcement', which is correct for those staff within range of the PA system at Turoa, which is located in the base area. Other respondents thought that 'staff' also made up a significant part of the warning system (11 %).

### 6.2.6 Confidence in RAL

Respondents were then asked if they thought RAL was prepared to handle a volcanic emergency situation (Figure 6.8). The majority of respondents (74%) indicated they felt RAL was prepared, however there were also respondents that did not feel that RAL was prepared (15%).

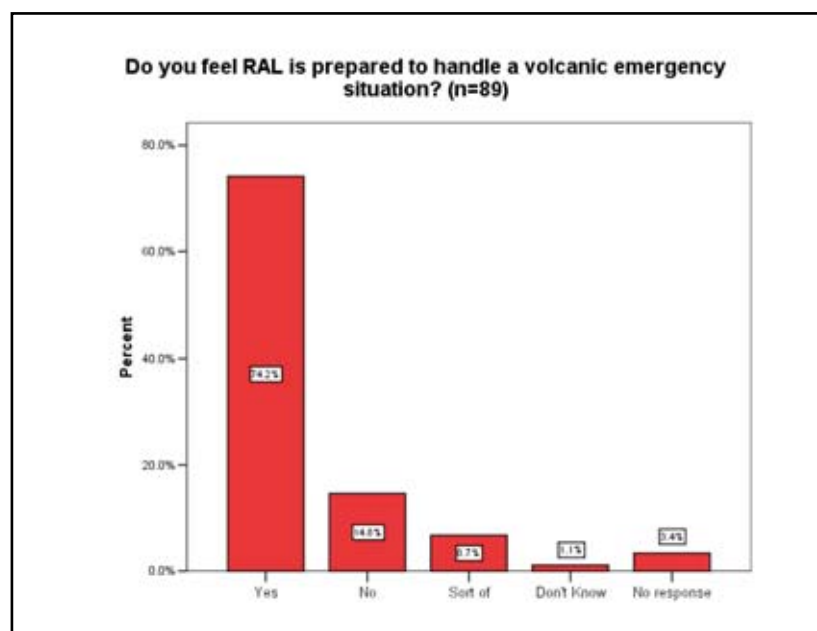


Figure 6.8

Respondent were then asked why they felt RAL was or was not prepared to handle a volcanic emergency. The main positive responses included 'because of the health and safety course' (25%), 'because they have a plan' (22%), and 'because of previous experience' (17%). Other responses can be seen in Figure 6.9. The most common negative responses were 'because staff should get more training' (5%), 'because staff don't know the evacuation procedures (4%), and 'because staff and public do not have enough knowledge' (4%). Other negative responses can be seen in Figure 6.9. Several staff were also unsure of whether RAL was prepared



to handle a volcanic emergency, because ‘they have not seen them in practice (3%), ‘they may not know what they’re doing (1%), and ‘a lahar is different than any other hazard’ (1%)

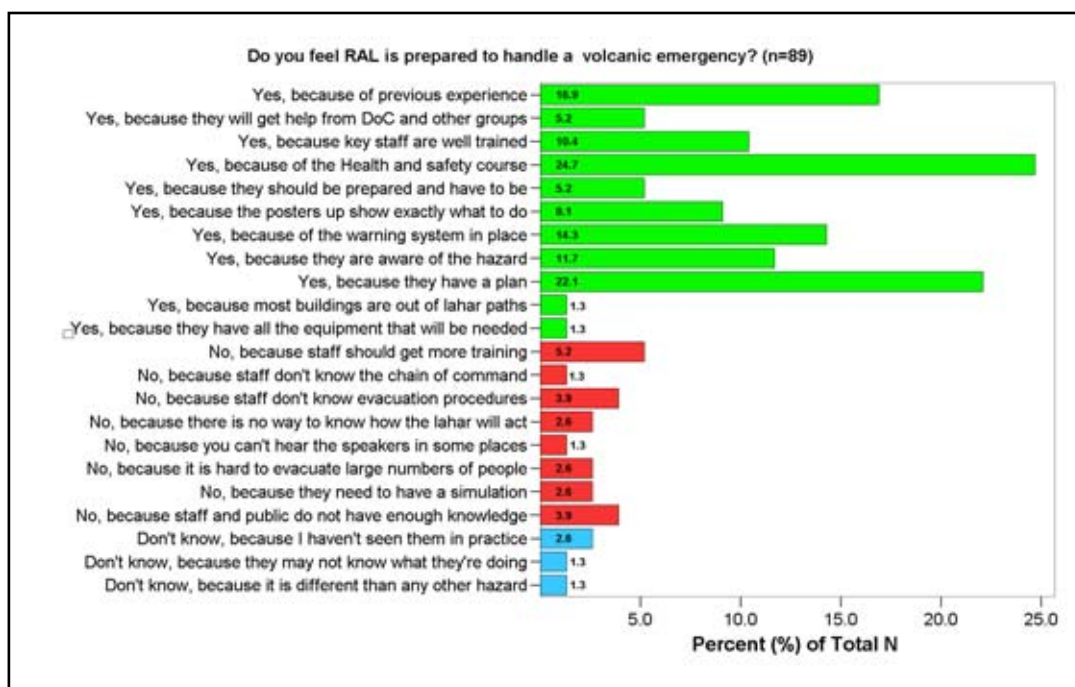


Figure 6.9

The high number of respondents indicating they feel RAL will be able to handle an eruption is not surprising, with many staff referring to the health and safety course, as well as the ski area having a ‘plan’ and experience in eruptions to explain their confidence. The majority of negative responses seem to circulate around staff not having enough training, and not having enough knowledge about the ‘plan’. This is often the outcome of the presumed existence of an ‘effective’ response plan, as it often lulls personnel and management into a false sense of security (Paton, 1996a) as it is believed that the plan will encompass and be able to handle every situation the emergency may present. First year staff are also often likely to have a more optimistic view of the company they are employed by.

#### 6.2.7 Role Requirements for response

The next question asked staff respondents if their role requirements during a lahar warning were explained clearly (Figure 6.10). 54% of respondents said their roles were explained clearly, with 26% saying their role was not explained clearly.

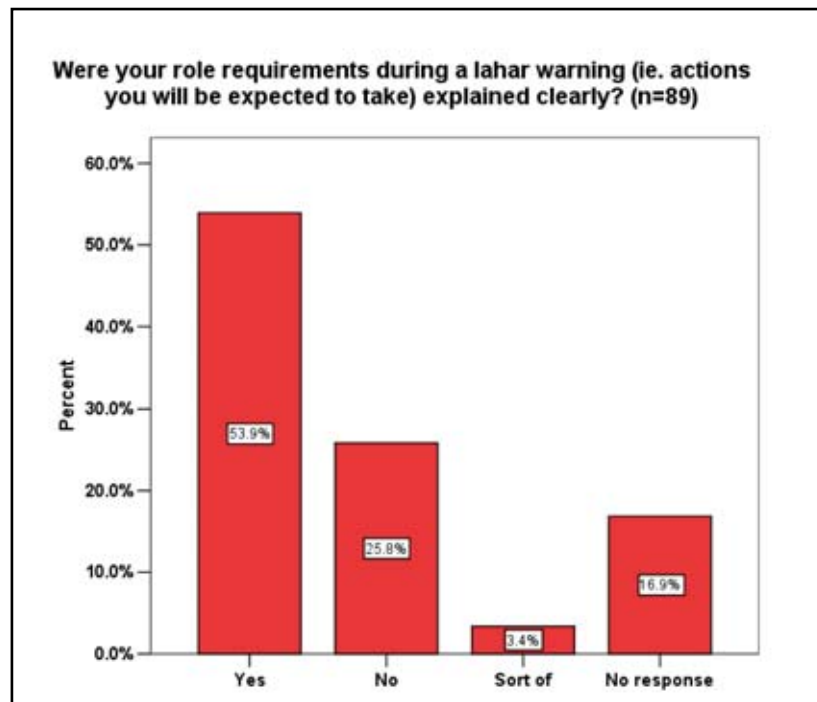


Figure 6.10

Staff were then asked to explain their role requirements during a lahar warning (Figure 6.11). The majority of staff indicated their role was to ‘move their group to a safe area’ (55%). Other common responses included ‘to calm people’ (23%), ‘move people to higher ground’ (17%), and ‘give out information’ (17%). Lift operators also specified that their role would include clearing customers off lifts. Of concern are the 8% of staff who indicated their role requirements had never been explained to them.

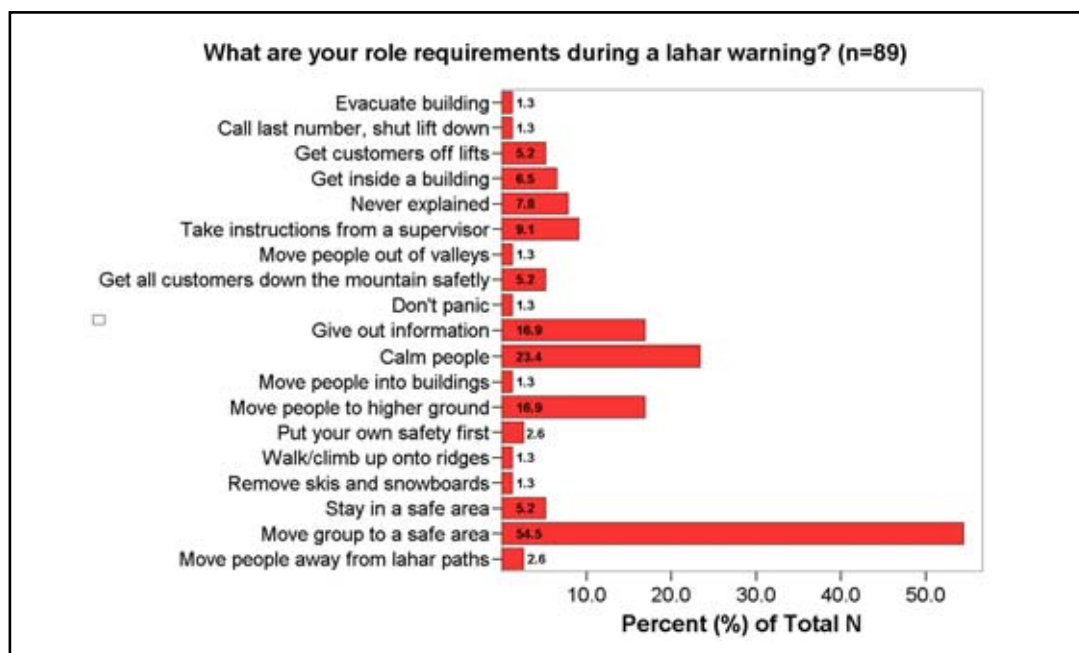


Figure 6.11

The responses given by staff were fairly similar to what they were told in their lahar training sessions during staff induction week. The only response action given that was never discussed is to 'evacuate building' (1%) which is the incorrect action to take as all buildings on both ski areas are in safe zones, and staff are encouraged to take a proactive role in keeping customers inside.

### 6.2.8 Working with others

Staff respondents were then asked a series of questions about working with others in their response role. Staff were first asked if their role included working with others, with 85% of respondents indicating 'yes' and 7% of respondents indicating 'no'. The next question asked if they felt their training for working with other was relevant. Many staff seemed to be unable to understand this question and skipped over this part of the survey. The staff that did answer the question were mixed in their response. 32% thought the training was adequate because 'I already work with people in my job', but 26% of staff thought the training was inadequate because 'I have not had any training for working with others in the case of an emergency' (26%). Other responses can be seen in Figure 6.12.



Figure 6.12

These results show the mixed confidence of staff at the ski area in handling a volcanic event. The responses 'I already work with people in my job' and 'I know how to work with people' show the common feeling of staff that handling a volcanic eruption will be relatively easy, as they will be able to apply common sense and daily job skills to the response effort and they discount how stress will affect their response. While this may be relevant in some ways, it is likely that staff

underestimate the potential high stress situation that may be caused by a volcanic event. Some staff respondents also mentioned the need to do a ski area simulation (10%). This has already been committed to by RAL and DoC, as a simulation and later-season blind test will be run every year, following recommendations by Leonard et al. (2004).

### 6.2.9 Response to a volcanic event

The next series of questions asked staff about what they thought could happen during a volcanic event at the ski area. The first question asked staff to specify what sorts of situations they think could be most stressful when the lahar warning system activates. Respondents indicated 28 situations they felt would be hardest to deal with. The most common response of staff was ‘panicking customers’, which was listed by 59% of respondents followed by ‘lost children/missing people’ (17%), ‘customers not knowing where to go’ (14%), and ‘people failing to listen’ (12%). Other responses can be seen in Figure 6.13.

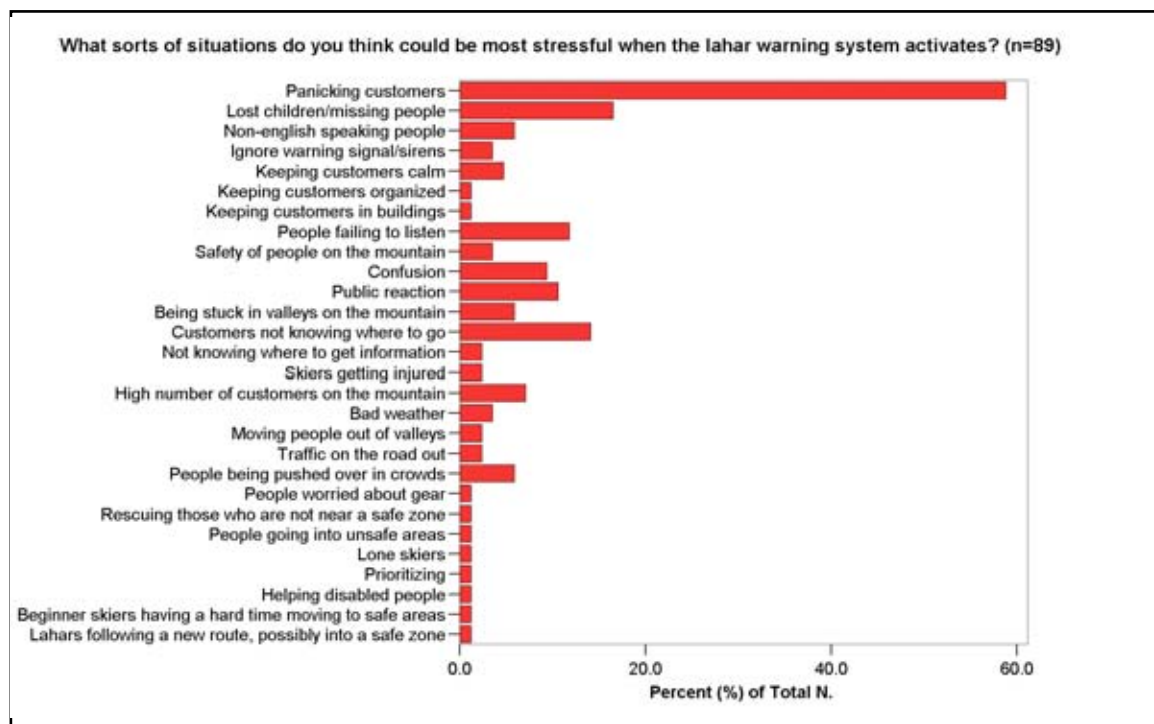


Figure 6.13

Respondents were then asked what the different possible reactions from customers to a lahar warning could be (Figure 6.14). Similar to the above question, an overwhelming majority of staff indicated ‘panic’ (84%), followed by ‘confusion’ (25%), and ‘fear’ (21%). There were also a certain number of staff who gave positive possible reactions, such as ‘interest/curiosity’ (8%), ‘calm’ (7%), and ‘asking a staff member what to do’ (5%). Less frequent responses can be seen in the following figure.

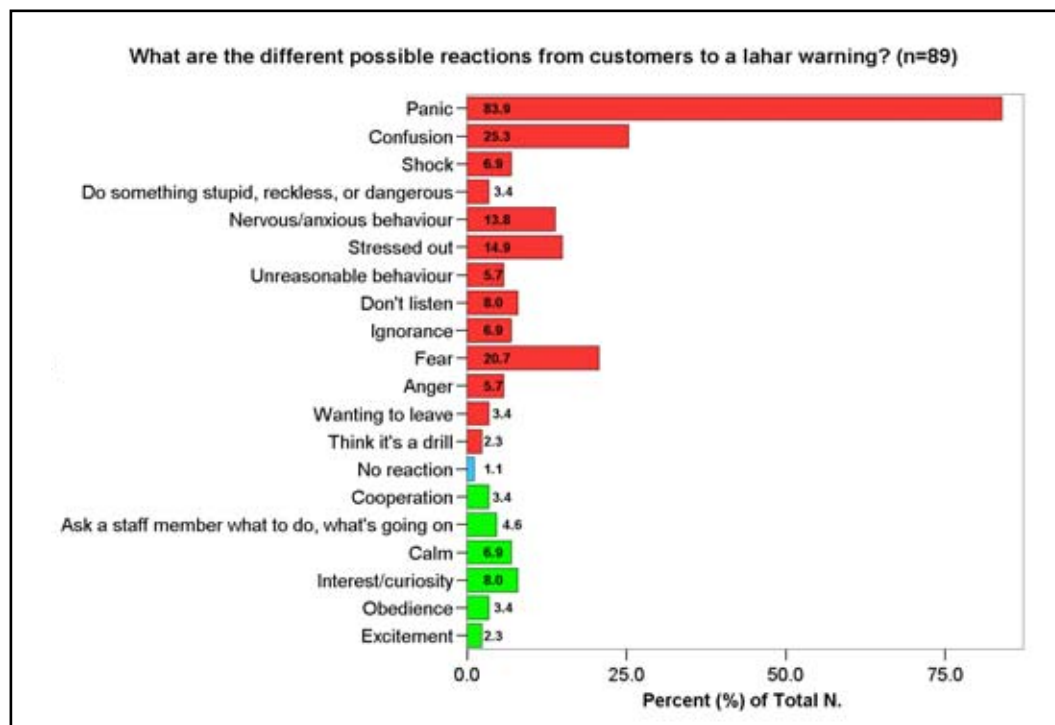


Figure 6.14

Respondents were then asked what customer needs they think they may have to deal with during a volcanic emergency. The most common answers were ‘providing reassurance/patience’ (31%), ‘letting them know what is happening’ (28%), and ‘location of family members’ (26%). Other responses can be seen in Figure 6.15.

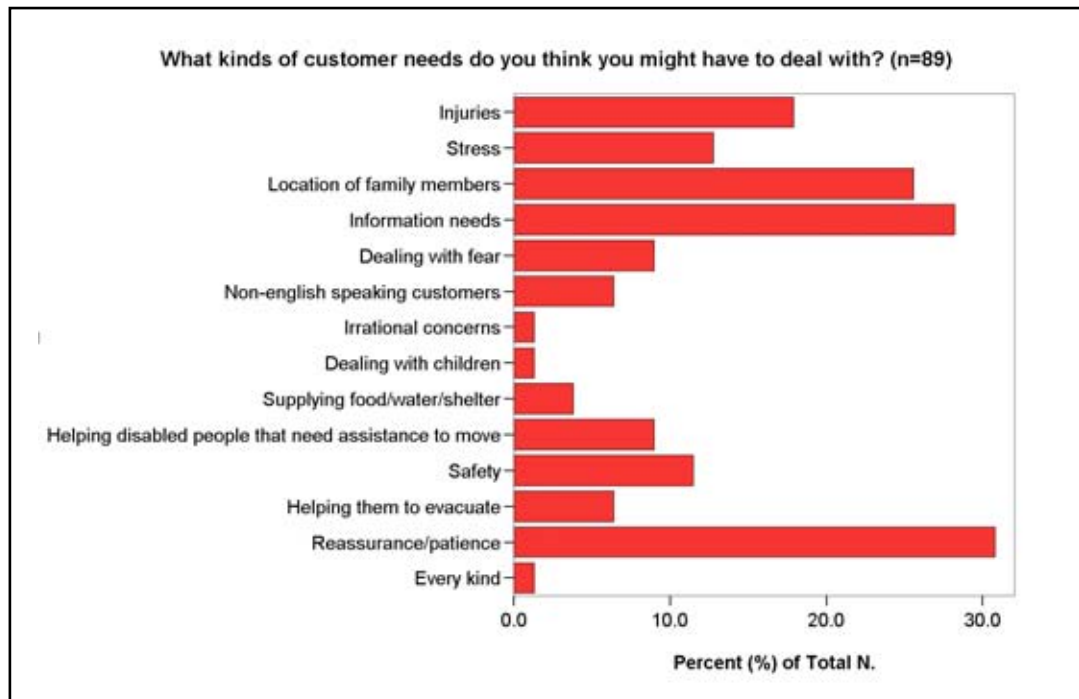


Figure 6.15

The high number of respondents who were concerned with handling panicking people is not surprising, as it was one of the possible situations that was stressed in various lahar hazard training sessions during induction week training at the ski areas. The high number of situations presented by staff in the three previous questions indicates that there are very different ideas between staff members of what exactly will happen during the response to a volcanic event. Such diversity can be positive, as Morrissey and Reser (2003) found during a study on cyclone preparedness that being able to anticipate, then recognize and manage such emotional responses as anxiety during the threat of a disaster was shown to enhance successful coping, promote preparedness, and reduce post-traumatic stress. Although a cyclone and volcanic eruption are very different events, as the warning time for the impact of a cyclone is much longer, this principle can still be applied a volcanic event. A staff member who anticipates different situations that may occur after the warning system has gone off will likely be able to handle them much better than a staff member who only imagines panicky customers as being a problem.

Staff respondents were then asked if they thought they had received adequate training to deal with these issues (Figure 6.16). Feelings were mixed on the training, as 51% of respondents thought the training was inadequate and 45% thought that training was adequate. However, the number of participants who thought the training was inadequate can also be turned into a positive, as it indicates that there was good uptake of the issues that will have to be addressed, and hopefully recognition of differences between routine work and emergency work.

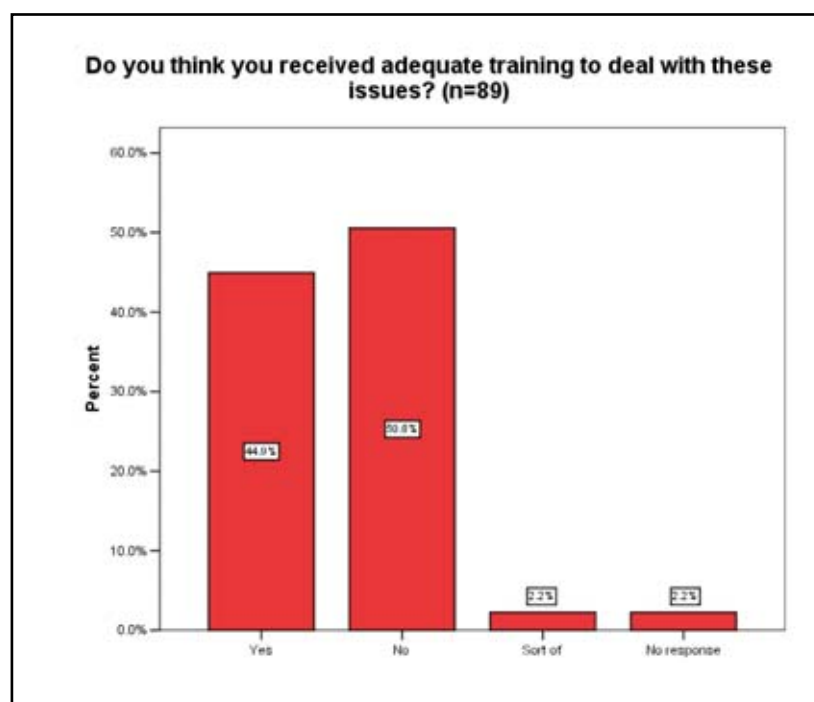


Figure 6.16

Staff were then asked why they felt the training was inadequate or adequate (Figure 6.17). Positive responses received included ‘the training received was already good’ (20%) and ‘because it is common sense’ (17%). The neutral response given for this question was ‘won’t know until it happens’ (6%). An alarming number of respondents ‘didn’t receive any lahar hazard training’ (34%). It is possible that these staff members did attend the health and safety training but could not remember any specific lahar hazard training or did not take it seriously as it was not central to their job. However, it is more likely that these respondents were employed by RAL after staff induction week or were returning staff who chose not to attend the health and safety session. This introduces



a dilemma for RAL, as it is difficult to train new staff for lahar hazards after the staff induction week as the ski area will then be in full operation and managers may not be able to take time to administer the safety course. Some staff who received the induction training at the beginning of the year may also leave the ski area before the end of the season, to be replaced by new staff who have not had any lahar hazard training. Therefore, staff will be joining the company throughout the winter season, so it is difficult to know when the best time of the season would be for a second training session.

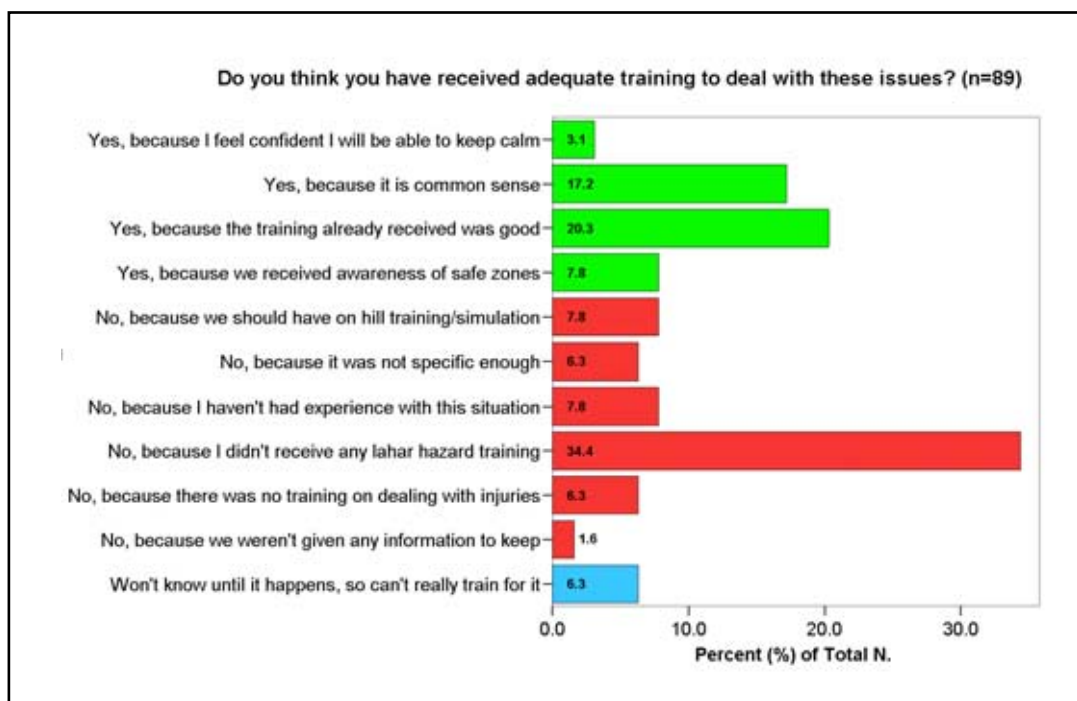


Figure 6.17

It is concerning that 17% of staff felt that dealing with the issues presented was common sense as the actual actions of a lahar response are not generally common sense reactions, particularly for international employees who have never lived in a geologically active area like New Zealand. For example, moving to higher ground, which means out of valleys and on to ridge lines, is not generally a common response to a ski area alarm sounding. As well, waiting in safe areas while the volcano may be erupting is also not a common sense reaction. This suggests that some staff underestimate what they may have to do, the time available, and how stress might affect their experience and actions.

The next survey question asked the potential consequences to skiers in the path of a lahar when it enters the ski area (Figure 6.18). 'Death' (74%) and 'injury' (41%) were the most common responses. Other responses included 'getting caught up in the lahar' (30%), 'getting



trapped/isolated' (9%), 'take out buildings/lifts that customers may be on/in' and 'getting caught in an avalanche caused by the lahar' (1 %). Most of these responses would likely result in death and/or injury to customers.

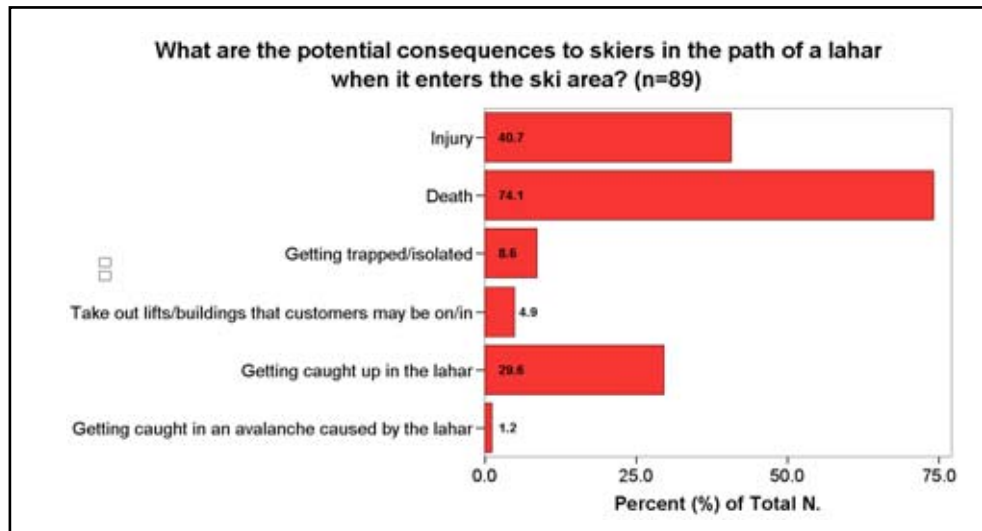


Figure 6.18

#### 6.2.10 Public Education

The final survey questions asked respondents if they had seen any public education on volcanic hazards at their ski area. 79% of respondents had seen some form of public education, whereas 20% had not. Respondents were then asked what the posters on volcanic hazards said. The most common responses were 'shows safe areas' (52%), 'procedure to follow' (43%), and 'shows possible lahar paths' (34%). Other responses can be seen in Figure 6.19.

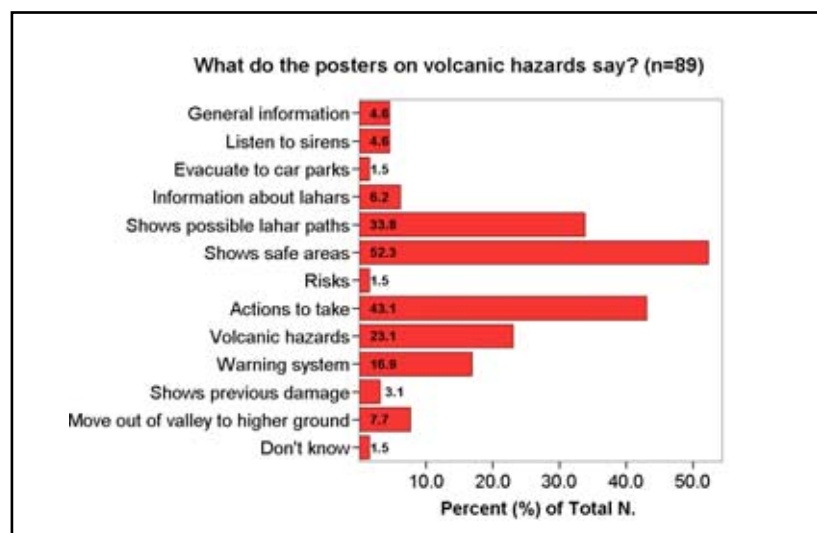


Figure 6.19

### 6.3 Staff Interviews

Interviews were conducted with staff at Whakapapa ski area. The first round of interviews was with permanent staff, and the following round of interviews was with first year seasonal staff. The interviews were designed to gain an understanding of staff awareness of the lahar hazard, estimation of the response effort, and confidence in RAL. Interviews were conducted with staff from Ski Patrol (2), Rentals (2), Food and Beverage (3), Retail (2), Customer Service (3), Road Services (3), Snow School (5), and Lift Operations (6). The results from the interviews only apply to Whakapapa ski area, unless otherwise indicated.

#### 6.2.1 Daily jobs

All staff seemed very comfortable discussing aspects of their daily tasks. All staff also seemed to have some knowledge of the 1995/96 eruptions, the impacts on the ski area, and the 1995 lahars. Most seasonal staff said the eruption was discussed in lahar hazard training, but is not usually mentioned in daily activities at the ski area. A few of the permanent staff interviewees had worked at the ski area during these eruptions. They seemed to believe that although the eruption in 1995 was fairly unexpected, the ski area gained a lot of knowledge from dealing with the eruption and the experience would help them in a future event. A permanent staff member mentioned

*“there was times when we were doing a wee bit of head banging and you’re getting people heading in the wrong direction, and um, not really coordinating things because it was the first time we’d had a major eruption on the hill. But this next time, I think things would go a lot smoother”.*

It is unknown whether any of the lessons learned from the 1995/96 eruptions were documented by RAL, despite numerous attempts by the author to find out. Another staff member said handling the past eruption made him/her more confident for handling a future eruption, because:

*“I’ve experienced it. I’ve been here. I’ve seen it. I know the procedures. I know that you have to move to higher ground and I know that you have to round up people and keep calm, keep them cool, and get them to higher ground, and access a way down”.*

Permanent staff also made reference to personal experience in eruptions or handling traumatic events much more than seasonal staff members. This is fairly unsurprising, as permanent staff have been working on the ski area much longer than seasonal staff and are generally older. Also, 50% of the seasonal staff hired by RAL tend to be international, who are likely not used to being around active volcanoes. The personal experience of staff is important for RAL to be aware of, as Drabek (1986) notes that specific events remembered by those who experience a crisis remain referent points, which are shared with others for decades to come, especially if no comparable event occurs. Therefore, the memories staff have of the 1995/96 eruption event (right or wrong) will likely be shared each year with new members of staff.

Ski Patrol and Lift Operations staff that were interviewed seemed to make frequent mention of other hazards experienced by the ski area, with the most common being avalanches. Avalanches have become a concern of late for both Whakapapa and Turoa ski areas, as many skiers and boarders have become eager to get into the backcountry. There have also been deaths at the ski areas due to burial by avalanches, which makes it a significant hazard for staff to deal with. In the past, a permanent staff member mentioned that:

*“lahars were sort of the furthest thing from our mind...we had so many more immediate problems”.*

This brings up a dilemma for RAL, as it is obviously difficult to focus resources on one hazard when others may seem more threatening. The following method is used by Ski Patrol to determine the amount of time they put into a specific hazard:

*“Frequency and severity...decides how much weighting we put on how much training and input we have into something. So something like a lahar, severity’s quite high, frequency’s relatively low, you know, so whereas, there’s a lot of other emergencies...that frequency’s a lot higher, severity’s quite high so we put more into training for them.”*

This stance is very understandable, as it is quite common in disaster planning for there to be competition between activities for limited resources (Paton, 1996a), even in organizations with much fewer daily hazards than the ski area. The goal then for RAL is to be able to develop a concise, informative training program in the time they allow for lahar hazard training, which also supports other hazard responses.

### 6.3.2 Lahar Hazard Training

Staff were asked about staff induction week and the lahar hazard training. The set-up for the lahar hazard training session was described by a course organizer as follows:

*“We pretty much identify that...it’s a significant hazard where we work...Pretty much the guts of how we look at it is two things. We kind of identify lahar paths to them, so look at the poster...and, um, and then we talk about actions, so we talk about how we’ll know if a, if a lahar is imminent, and what, what actions they should take as to where they are.”*

Most staff mentioned they were told about where the safe zones were and their initial response actions. Four of the 26 staff interviewed (two seasonal, two permanent) had never attended the lahar hazard training, however they all seemed to have informally picked up the general points covered in the training session. One staff member indicated

*“I never know where they are or what it does. I’ve only, all I’ve seen is the, you know, just a pamphlet they give out to read. That’s all I’ve had”.*

A few permanent staff members made reference to how much the training had improved this year compared to the last few years, as this was the first year that the lahar hazard training was provided

in separate departmental sections. However, many seasonal staff felt that training could only help people handle an eruption event to a point. For example, one response received was:

*"I think information is always good. The more you know the better. But, um, there can be people that you can train forever and ever, and they're just panic-stricken people no matter what you tell them. They're just gonna go psycho, you know. I definitely think it's necessary to get training, just so you know what's going on...I don't know, in the end I think it...boils down to character."*

This is a common attitude to have, however it tends to encourage inactivity in regards to the lahar safety training. It insinuates that training is only beneficial to a point, and anything after that is a waste of time. However, it is true that personality type is a large contributor to how one is able to cope with a disaster.

### 6.3.3 Eruption Event

Staff were then asked a series of questions about an eruption event at Ruapehu, such as the hazards associated with a volcanic event, the frequency of eruptions, and the effect of an eruption on the ski area. Seasonal and permanent staff were all knowledgeable of the possible hazards to the ski area during an eruption, with the main one mentioned being lahars, followed by ash fall and rocks. Staff were also confident in defining a lahar and the likely effect of one on the ski area, although two seasonal staff members defined a lahar as flowing lava.

Most seasonal staff gave the frequency of eruptions at 10 to 20 years, whereas most permanent staff thought the time was longer between events, with frequencies from 10 years all the way up to 50 years being given. Seasonal staff were more likely to call on lahar training and the public education posters as their sources for the information about event frequency, whereas most permanent staff verbally calculated the frequency relying on their memory of past events. It is then not surprising that permanent staff members tended to indicate longer frequencies, as the eruptions recalled were in 1975 and then again in 1995. Many did not seem aware of all the smaller but potentially dangerous eruptions that occurred in the last 50 years at Ruapehu. A common result of underestimating the frequency of events is known as gambler's fallacy (Morrissey and Reser, 2000, and McClure and Williams, 1996). The simplest way to describe this psychological reaction is that gamblers tend to judge their chances of winning to be higher when they have previously lost a gamble (McClure and Williams, 1996). Therefore, because the last eruption occurred in 1996, and one thinks the frequency of a return event is 40 years, then they feel it is unnecessary to take

preventative actions because the next event will not happen for 40 years time. Also, because no one has been killed in a previous eruption event on the ski area (the Tangiwai lahar disaster was not related to an eruption), most staff may believe that the next event will also have the same result.

All staff on the ski area seemed to be accepting of the fact they were working on an active volcano and had to be prepared for an eruption. One staff member reasoned:

*“You’re on an active mountain, you know. It’s something you’ve got to think of daily. Admittedly, I don’t think I think about it all the time, but it’s one of those things I’m aware of... being up here and working up here it’s something you have to keep an eye and ear out for.”*

Seasonal staff seemed very curious and interested in an eruption. Many indicated they thought it would be “cool” if there was an eruption during their time working at the ski area. These same staff members also seemed very confident that RAL was sufficiently prepared to handle an eruption and were optimistic the response would go smoothly. Interestingly, these staff also indicated that an eruption would likely result in closure of the ski area and loss of their jobs, and possibly death and injury. Many staff members who mentioned death or injury as a consequence seemed to imply it would be other people in danger, not themselves. This is referred to by McClure and Williams (1996) as unrealistic optimism, where one displays a sense of personal invulnerability; they believe they are much less likely than the average person to suffer misfortune. A consequence of this outlook is generally an underestimation of risk. In this study it was found that those staff members who indicated death and injury as a consequence to a volcanic event (although none specifically referred to the possibility of themselves dying or being injured ) were generally also the most concerned about the volcanic hazards, initial response, and ski area evacuation.

Many staff also indicated they were concerned the volcano could erupt differently than it had in the past. Issues raised by staff included that the lahars may travel down a different path than expected possibly into safe areas, the lahars may enter the ski area quicker than they had in the past, the lahars may be bigger in size, there may be no warning signs preceding the eruption, and most commonly that the eruption may be much larger than past events. Generally staff seemed to have a defeatist attitude in regards to a different style event. A common opinion found was:

*“The whole mountain could blow up, like the whole mountain, a really big chunk, like the top half goes flying or something. I don’t actually know the probabilities of that happening, but that’d be interesting. We’d all die, but it’d be crazy.”*

Other staff members used the possibility of a larger eruption for proof that lahar hazard training was irrelevant:

*“If it was the biggest, like if it was a pyroclastic eruption, it wouldn’t matter what courses I did, I’m gonna get incinerated. I can’t run fast enough to get away from that.”*

Morrissey and Reser (2000) believe this is a natural reaction to a stressful situation, as repeated thoughts that the event is an awesome and uncontrollable ‘act of nature’ can create feelings of helplessness resulting in the justification of not taking preventative actions. On the ski area, these feelings can result in staff not taking training and a warning system alarm seriously. More importantly, it may also result in ski area management taking a negative view towards preparing for a larger scale volcanic event situation. It then becomes important for RAL to direct attention away from the fear-inspiring ‘volcanic eruption’ to concrete actions that one can take to protect oneself, which limits the attitude towards fatalism (McClure and Williams, 1996).

Another issue causing confusion about a volcanic event at the ski area is a Crater Lake tephra barrier failure lahar (Section 2.3). A few staff members, both permanent and seasonal, indicated they thought the barrier failure lahar could affect the ski area. A few staff members indicated that it was likely to do so in the next few years. The reasons for this thinking are likely related to increased media coverage of a Crater Lake break-out lahar, particularly in the local newspaper, which at the time was publishing a weekly information box on the status of the Crater Lake. The easiest way around this confusion is for it to be stressed during the lahar hazard training session that a break-out lahar will not affect the ski area, as only an eruption has the potential of ejecting water into a position where a lahar may be formed above the ski area.

However, despite staff knowledge of the volcanic hazards, many were still very uncertain about the eruption event. A few seasonal staff indicated that flowing lava would be present and many staff had no idea if there would be warning signs before an eruption. Many had not heard of the idea of a ‘blue-sky’ eruption, judging from the following two responses, the first from a permanent staff member and the second from a seasonal staff member:

*“I’d say there’d definitely be warning signs, from what I understand. And that would be, it could be in the form of thermal, thermal eruptions, or it could be seismic activities,”* and

*“I don’t think...an eruption would be that spontaneous that you’d have to, that you’d have a full mountain of people to, to get everybody off, do you know what I mean?”*

If staff believe they will receive warning before an eruption, they may feel it is unnecessary to learn the proper response actions as they assume they will either not be present on the ski area or will have time to find out what to do when an event occurs. However, it is often difficult to interpret signals given by a restless volcano (Peterson, 1988), such at Ruapehu. It is therefore important for management to stress the possibility that the eruption could be a ‘blue-sky’ event and the importance of preparing for that and that stress will affect what they can do.

More concerning is the lack of knowledge about the likely warning time between activation of the warning system and a lahar entering the ski area. Only three permanent staff members knew the 1995 lahars entered the ski area within 90 seconds, and they estimated the warning time for a lahar in the future would be similar. It is constructive to base response capabilities on the worst case scenario, because if staff can respond to that they will be able to deal with any other eventuality. Seasonal staff were very unsure of the potential warning time, with most being unsure and others stating the warning time would be over 10 minutes. A few Snow School instructors indicated they would likely have time to ski their classes to the bottom of the ski area:

*“I’d get off the mountain....I’d get my students probably to ski in front of me and I’d ski behind. And get them all down and get their skis off. Ski, and then, just, ya, get to the carpark and evacuate, just get out.”*

It is likely that this instructor would not have the same response plan if he/she knew the warning time could be around 90 seconds, similar to the 1995 lahars. Therefore, the warning time must be quantified in training, as to say ‘not long’ means different things to different people, and then stressed repeatedly by indicating the need to quickly get to higher ground.

#### 6.3.4 Warning System and Tests

All staff interviewed were reasonably knowledgeable of the warning system at the ski area. All knew it existed, and that a siren and announcement would be broadcast over the ski area. However, permanent staff were more concerned about the warning system than seasonal staff. A few raised concerns over whether the warning system would actually be triggered by an eruption, and also whether they would be able to hear it in their position on the ski area.

Issues regarding the testing of the warning system were also brought up during the interviews, with permanent staff having much more to comment on the issue. This was likely because their extended employment on the ski area has resulted in them being present for past simulations, blind tests, and false alarms of the warning system. Permanent staff had very positive opinions of simulations performed in the past, and seasonal staff seemed to feel their lahar hazard training would have been more complete if they would have participated in a simulation (which they were due to have approximately one week after the interviews were conducted). A seasonal staff member reasoned:

*“There’s not been like a drill or anything where we can all actually see for ourselves what we’re meant to do. I mean, it’s alright them explaining it to us in, in a comfy room down here. But when it’s up there, and it’s happening and there’s noise and people shouting stuff...”*

Opinions on blind tests of the warning system were mixed amongst permanent staff members.

Some felt that blind test were very important:

*“Because it keeps people on their toes. It sees what actually people are actually gonna do rather than getting reminded that morning ‘alright, so you’re gonna be on this lift at that time and when that happens you do this, and...’. I think with a volcanic emergency then, um, you’re not really gonna get told what to do.”*

However, the same staff member later said that he/she believed a simulation was much more effective than a blind test at teaching staff their roles during a volcanic event. Permanent staff members generally also felt concerned about the loss of urgency with regards to the response to an alarm. For example, one staff member said:

*“Well from what I’ve seen, whenever we’ve done practices, um, people generally, or not generally but often, just, just ignore it. People in the valleys often just fall over and lose all of their ski gear and spend the next sort of 10 minutes picking it up and trying to get it back on, just standing in valleys.”*

Nevertheless, many of these same staff members thought it was very important to have tests of the warning system, but implied the importance of having a balance between making sure that the warning system is working well and desensitizing people. The concept of desensitization is discussed by Morrissey and Reser (2000), as it is common for one to feel that nothing is going to happen after hearing a number of warning messages that do not result in an emergency. The anxiety that accompanies the warning messages may become switched off, causing one to stop listening and attending to the warnings. It was stressed to groups during Whakapapa staff induction week that staff should treat all alarms as real, however it may be important to repeat the importance of responding quickly to the alarm which may go off multiple times in a single season.

On March 22<sup>nd</sup>, 2005, there was a false alarm at the ski area due to a power failure in Whakapapa Village and subsequent failure of the back-up batteries. The lahar warning alarm was also triggered for Whakapapa Village. The alarm ended up ringing on the ski area for 15 to 20 minutes, and RAL staff were unsure of whether it was a real alarm. RAL staff were eventually informed after contacting the DoC Visitor Center that it was indeed a false alarm. However, RAL still had customers up on the ski area who were not notified and several ended up calling ‘111’ to determine whether it was safe to come down. RAL was only aware of these customers after they received a call from the police in Wellington. The customers eventually walked down the mountain but were very upset at not being notified it was a false alarm.



Management at RAL found their staff response on the day disappointing, stating that:

*“I think the key, the disappointing thing about that day was just, was probably....I had a feeling that most people...in the company probably assumed it was a test.”*

This brings up another issue for RAL, which is their preparation for an alarm in the off-season and how they will notify customers on the ski area. It is a very different situation than the winter, as in the summer the RAL operating area only extends from their lift at the bottom to the top of the top lift for people using the lifts to get up to the Crater Lake. The situation also will likely not be as dangerous in the summer, with less people on the ski area and less snow. The most important issue that was raised during the false alarm was the desensitization of staff to the alarm, as most ignored it, however customers on the field who were hearing it for the first time were quite flustered. This issue likely lies more in the hands of DoC than with RAL, as DoC is able to make an announcement over the entire ski area at any time. It would have been beneficial during this situation for DoC to broadcast a false alarm statement as soon as possible, which should be a lesson taken from this false alarm.

### 6.3.5 The Response Plan and CIMS

The concept of a response ‘plan’ was also brought up often by staff members during the interviews, particularly Ski Patrol staff. Most seasonal staff members were confident the ski area would have a plan, as can be seen in the following response:

*“They’ll have it sussed. I’m sure they’d have to. They’ll have to for legal obligations anyway. They’ll have to have like a 100 page document on what to do, what would happen, all the different scenarios, and how to combat them.”*

Staff members who held this optimistic view of a ‘plan’ were also likely to be very optimistic about the response effort. As discussed in the previous section, this is often the outcome of the presumed existence of an ‘effective’ response plan, as it often lulls personnel and management into a false sense of security (Paton, 1996a).

However, there is currently no specific eruption response plan at the ski area. As far as the author could tell, there is a broad plan for responding to emergency situations that would be applied to a volcanic event. A member of Ski Patrol justified this approach:

*“I guess the attitude we try to take is that many of those emergencies on the surface are, um, the same. It involves a certain amount of people that are in a certain amount of stress and need to get somewhere, um, and, and that’s really what, what it comes down to, ya.”*

However, this idea of a generalized emergency response plan did not seem to resonate with other

staff members. Another permanent staff member requested a more specific plan:

*“I would like to know there was an overall action plan and I would like it divided down departmentally into what we do and what our role is within that, and who we talk to from our role within that. I’d like it to be organized before it happens.”*

Staff were also questioned about CIMS (a formalized emergency response plan), which the ski area may hope to employ in their response to a volcanic event. A member of Ski Patrol described that

*“we have done some CIMS training with the key management here, um, which has, I think will help in the management of the longer term evacuation”.*

Only three staff members, two from Ski Patrol and a former Medical Center nurse (currently in Customer Services), had any idea what CIMS was. However, all three were very positive about the potential for implementing a CIMS structure during a response. A member of Ski Patrol described the benefits of using CIMS:

*“Basically, just gives you a structure and a systematic approach to dealing with stuff, and, um, it’s a way of learning from, historically from mistakes at big incidents. And, um, and come out with a system which will guide people through that and avoid making the same mistakes. It’s a really good way of recording all the actions of what happened, and, um, and it assist with the decision making process which promotes a group decision making.”*

It is likely that if a CIMS structure would have been used at the ski area during the 1995/96 eruptions, the response of the ski area would have been documented so current management could learn from the mistakes made in 1995/96. However, if most members of management staff at the ski area are unaware of CIMS, then it is likely that using it in a response to a volcanic event would be impractical.

There has been talk on the ski area during the 2005 winter season that a detailed CIMS plan will be developed for the response to a volcanic event by the Safety Services department. If so, it is very important that this document is developed alongside the DoC Eruption Response Plan, so that the two plans can feed positively off one another. The plan should be backed up by regular simulations and exercises involving all staff and reviewed and re-developed as a result of the evaluation of these simulations and exercises.

### 6.3.6 Stage 1 – Initial Response

The response to a volcanic event was divided into two parts by Galley et al. (2003):

- Stage 1 – initial response
- Stage 2 – evacuation of the ski area

Most staff members interviewed seemed very confident in their role requirements for the initial response to activation of the warning system, particularly Ski Patrol and Lift Operators. Permanent staff often reiterated the need to stay cool, calm, and collected, as customers will look to them for help. Other staff members were very optimistic about the response effort, such as the following:

*“I think that as long as the staff have a base knowledge, with the experience that they have up here, that they can assume the worst and hope for the best, and rely on the public to be as patient and as understanding as they can be.”*

A few staff indicated they were very confident because they worked at the ‘Top of the Bruce’ area, which is a safe zone, so they did not feel they would be in huge danger. Although it is good for staff to be optimistic, overestimating response capabilities and underestimating risk can constrain disaster/crisis planning (Paton, 1996a) and may lead to an organization being not properly prepared for an emergency situation.

The only ski area departments that seemed to be a bit confused of what they are supposed to do was Snow School and Food and Beverage staff. Snow School Instructors were concerned about how they would be notified about a volcanic event if they could not hear the warning system, as Snow School instructors do not carry radios. A few instructors indicated they would try to ski their classes to the nearest lift station instead of immediately taking to higher ground. An international Snow School Instructor indicated he/she was confused about locating safe areas during an eruption event:

*“I mean, we’ve got the maps, we’ve got the lahar safe areas. But when you’re actually on the mountain, it’s not, uh, certain where they are. I mean, when you’re skiing along as it is, it’s hard to know where you are. And especially if it’s bad weather as well...it’s hard to, sort of, orientate yourself.”*

It was suggested that safe areas be marked with green flags so that customers and staff will be able to know where to go. However, this is likely unrealistic because it creates more work for Ski Patrol to make sure that the flags are maintained and would also create an expectation in users that only flagged areas are ‘safe’. A more realistic solution would be to clarify in lahar hazard training that higher ground anywhere on the ski area is always a safe area. An animation of how a lahar moves down valleys may help to get this point across. It would also eliminate confusion if Snow School Instructors were to carry radios. This would be beneficial not only for a lahar response but also in

the general running of the ski area. Food and Beverage staff seemed confused about whether they should keep customers in the building or evacuate them outside. A simple solution to this problem, as suggest by a few staff members, would be to utilize the building fire warden also as an 'eruption' warden. They could easily be trained the proper response during a lahar warning system alarm, and could take a leadership role amongst other staff in their building.

Permanent staff raised many more concerns about the initial response than seasonal staff did, particularly keeping staff and customers safe. Some staff members indicated that:

*"it's a very intimidating thought 'cause I don't really want to be involved in it. I'd rather watch if from a distance", and*

*"It would be scary because I'd be on my own. I'd have to deal with all these people on my own".*

A few staff members raised concern that seasonal staff were expected to know what they needed to do, however it was likely that many of them would be unsure of what to do in an actual eruption event. One seasonal staff member explained "

*"I think they think we have more knowledge than we actually do".*

This may lead to confusion in an event response, as staff may not act immediately and may crowd the radio channels requesting instructions. Also of concern, especially amongst international staff members, was that many customers on the mountain may be inexperienced and unaware of what to do. RAL has tried to prepare for this problem, with the introduction of a poster public education campaign in 2004 at Whakapapa (David Johnston, *personal communication*, 2006).

Snow School staff seemed to be the most concerned about customer safety. Each Snow School Instructor interviewed indicated that they would feel added stress in an emergency situation due to having the responsibility of looking after their classes. Several comments include:

*"You're responsible for those children, so you wouldn't want to make a wrong move, send them places where they shouldn't go, take them places where they shouldn't go," and*

*"You're responsible for their, their lives, like, and you know you hope you make the best decisions based on the circumstances and on their ability."*

Snow School instructors will have added responsibility during a volcanic event compared to other ski area staff. It is possible they may have a class of students with them, and it is likely those students would be children away from their parents. Due to the added pressure of not having a radio, it would be difficult for Instructors to get instructions on the evacuation procedure and to inform management staff of the children they have with them. This added responsibility should be explained to Snow School Instructors during lahar hazard training, as it will likely result in them being more concerned about knowing the proper response actions.

### 6.3.7 Stage 2 - Evacuation

Staff were also asked about Stage 2 of the response procedure, which would be the evacuation of the ski area. All staff members were very uncertain about this stage of the response. Ski Patrol staff made the most mention of the evacuation procedure, however when questioned were very uncertain about what would actually take place during an evacuation. It was mentioned that a broad evacuation plan would be applied to an evacuation during a volcanic event. However, there could be problems with applying a broad evacuation plan, as parts of the ski area may be isolated by lahar paths and ash fall on the ski area may make mobility difficult. All staff seemed very uncertain about who would be in charge of the evacuation, and how they would receive information about what to do. A seasonal staff member showed their confidence in RAL:

*“Um, I’m sure they’ve taken...I’m sure when they study the mountain that they must think ‘oh, ok, maximum, great day, how many people do we have on the mountain, how will we evacuate’. They must do that.”*

However, no one seemed to have any idea how long it would take to evacuate the ski area, with answers ranging from an hour to an entire day. It was also found that no one was exactly sure of just how many people would need to be evacuated: seasonal staff estimates ranged from 2,000 to 20,000 customers on a busy day, and permanent staff estimates ranged from 4,000 to 12,000. This suggests that no one has worked out just how many people may be in each location on the mountain, how long it would take to get people down, or how many people would be on the mountain in total. Many seasonal staff indicated they would like a broad overview of how an evacuation of the ski area would work during the Health and Safety training, particularly on who would be heading the evacuation effort.

### 6.3.8 Communication

Staff also spoke about communication during a volcanic event. Permanent staff were more concerned about the method of communication and how they would receive information about things such as the status of the eruption, while seasonal staff were more concerned about how they would receive instructions. There were four methods of communication mentioned: radio, cell phone, landline, and verbal. Radio was found to be the main method of communication mentioned by the staff members. Because Snow School Instructors do not carry radios, they were more likely to refer to cell phones as their main method of communication. It is possible that radios may go down during a volcanic event, so the ski area would next rely on cell phones. However, during the 1995 eruption at Ruapehu, cell phone services in the area were overloaded, collapsing cell phone networks (Peter Blaxter, *personal communication*, 2005). Due to increased cell phone usage

between 1995 and 2005, it is possible that cell phone networks in the area would be overloaded again during a volcanic event.

Many seasonal staff indicated they would like to have instructions before beginning any response to the warning system:

*“probably the first think that I would do would, uh, look for some sort of supervisor or something to get instructions from”.*

Lift Operation seasonal staff seemed the most dependent on instructions from supervisors or management staff. However, permanent staff members generally had a different view:

*“I think with a volcanic emergency then, um, you’re not really gonna get told what to do”.*

Staff also believed that information about the volcanic event and response would constantly be passed to them. For example:

*“They’d be letting us know over...wireless. Every now, every now and then they’ll be giving us an update. They’ll be saying what’s going on, what’s occurred, what’s happening, what’s been taken out.”*

This is a fairly optimistic opinion of what will happen on the day, and shows the general trust seasonal staff have in the management at RAL. It is likely that during a volcanic event the management staff will have no idea what is happening with the volcano and what the damage is, at least for the first few hours. This brings up another communication issue, as management at RAL will have to be in communication with DoC and GNS about the status of the volcano and what their actions should be. It is best if this communication procedure is worked out beforehand, so RAL will immediately be able to get in contact with an outside information source. The response to the 1995/96 eruptions involved 42 organisations (Johnston et al., 1999b), which gives an idea of how stressful communication (particularly trying to find out information from other organizations) may be during a volcanic crisis.

Staff had different thoughts on who would be responsible during a volcanic event. Permanent staff were more likely to indicate Safety Services (Ski Patrol) and DoC as being responsible for handling the event. Seasonal staff were more likely to be reliant on their managers and supervisors. Ski Patrol members mentioned DoC as being responsible more than another staff member. Because they are deemed by most staff as being responsible for the response effort, Ski Patrol and management staff must show a keen interest in the volcanic hazards as the ski area, because organizational commitment to the programme is vital to its success (Paton, 1996a). This can be achieved by having responsibility vested in a key figure on the ski area, such as the Safety Services manager.

The importance of evacuation, communication plans, and information management at ski areas was recently shown during an incident in Lake Louise, Canada, when a gondola broke down, stranding skiers for up to 5 hours. Children were stranded on the gondolas away from their parents, and minimal effort was made by the ski area to communicate with parents. The resort claimed the evacuation was done according to protocol, using 120 personnel, and that delays were due to the fact that the evacuation was taking place in a dangerous environment. However, the resort should have anticipated that any rescue on the ski area would likely take place in a ‘dangerous’ environment. One parent said “communication is key and in this case communication -- for myself on the ground, and my sons in the air -- was pretty much non-existent. My sons were literally and figuratively in the dark” (Tetley, 2005). Customers called the response an “absolute fiasco, the lack of every kind of organization one would expect”, the resort’s evacuation plan “flawed”, and demanded cash compensation from the ski area (Monchuk, 2005). However, it is likely that if communication would have been better between the ski resort, those in the gondolas, and those on the ground that many negative feelings and bad press would have been avoided. This is an important lesson for RAL to learn, as communication between groups both on and off the mountain will be vital to keeping customers and staff calm during a volcanic event, which will be a much more demanding situation than a stopped gondola.

#### *6.3.9 Stressors*

Staff brought up many potential stressors of responding to a volcanic event during the interviews. All of the following situations were mentioned multiple times:

- Job loss
- Closure of the ski area
- Damage to lifts and buildings
- Public reaction
- People scared away
- Problems with the Bruce road
- Finding people on the ski area
- High number of customers
- People isolated by the lahar
- Having to wait for instructions
- Finding out-of-bounds skiers

The most commonly mentioned stressor was public reaction. Most staff interviewed believed that the public reaction would be negative, with customers not taking the alarm seriously, panicking, and not listening. A permanent staff member thought the biggest issue would be

*“...panic. People will panic and so therefore people don’t listen and things get out of control”.*

However, another staff member thought that opinion was likely an overreaction. He/she thought:

*“it’s funny, I think, you think there’s gonna be widespread panic and screaming. But I don’t necessarily think that’s gonna happen”.*

As discussed in the previous section, it is positive to find that staff members are thinking of many possible situations they may be placed in during a volcanic event. Morrissey and Reser (2003) found during a study on cyclone preparedness that being able to anticipate, then recognize and manage such emotional responses such as anxiety during the threat of a disaster was shown to enhance successful coping, promote preparedness, and reduce post-traumatic stress. Interestingly, Ski Patrol staff did not mention public reaction once during their interviews. Their interviews had a more militarialistic feel to them, as they discussed responses, procedure, and plans, but did not seem concerned about public response.

Staff also mentioned consequences to skiers as a result of a volcanic event. The most common responses were death and injury, with permanent staff generally mentioning death and injury much more in their interviews than seasonal staff. Staff who did not mention death or injury as a consequence to a volcanic event generally seemed much more confident in RAL to be able to handle a volcanic eruption, and also in volcanologists to be able to predict an eruption. One seasonal staff member indicated:

*“they assume in the past it’s always been quite insignificant, that no one’s really died from it, other than the train years ago. But I guess they don’t, it’s not usually a huge life risk, is assumed”.*

It is important for staff to understand that there are real risks associated with a volcanic event and there are steps that can be taken to lessen these risks, as denial of risk generally leads to unpreparedness (McClure and Williams, 1996).

Staff were also asked about their views on coping after a volcanic event. A member of Ski Patrol outlined the likely response the ski area would take after a volcanic eruption:

*“If it was just an eruption, we’d close the field and nothing happened, we’d debrief it definitely and from a technical point of view. And of course, the option would be to put up to everyone do they want to sit and talk about it, you know, psychologically or do they want to seek further help”.*



Although the majority of permanent staff mentioned debriefing as a coping method, no seasonal staff mentioned debriefing, likely because they are unaware of what debriefing is. Most staff felt that coping was individual, as some people would have no problem recovering from a traumatic event while others may have a hard time. Most staff members thought that they could easily handle the stress of an eruption, like the following comment from a member of seasonal staff:

*“I wouldn’t be that worried about it. I would be sad about not being able to snowboard the rest of the season...I don’t think it would be necessary to give stress counselling....It probably would be upsetting, but I wouldn’t, it wouldn’t ruin my life I don’t think. Um, but for some people, ya maybe. Some people would feel really bad”.*

This again shows the personal invulnerability attitude that many staff had, by discussing how others may need help but not them. Staff were against mandatory counselling sessions, instead believing that one should request counselling if they would like to talk to someone.

Because of the danger associated with working on a ski area and past traumatic events involving staff and customers, RAL has good relations with counselling services in their area and would likely be able and willing to provide that kind of support to staff members. However, in order for staff to make use of these services they must be aware of them. Paton (1996a) stresses that “training should cover the causes and consequences of traumatic stress, the development of realistic expectations about personal vulnerability, promote the use of appropriate coping strategies, and increase their awareness of the benefits of utilizing support services” (p. 212). These topics could easily be covered very quickly in the Health and Safety training session during induction week, as these issues can apply to many situations on the ski area, not just a volcanic event.

#### 6.3.10 Public Education

Staff were also keen to discuss the volcanic hazards public education program in place at the ski area. Permanent staff mentioned that the ski area had been working hard to increase public awareness of the volcanic hazard, and the newest addition to that effort was mailing out ‘Volcanic Hazards at Whakapapa’ brochures along with season passes to all season pass holders at the ski area, which this year was 25,000 skiers. Most staff believed the program would raise customer awareness, leading to an improved response efficiency:

*“Well because the more the public know, the easier it is to deal with them. If they’re totally oblivious to what’s going on, well then it’s a hard, hard to explain it to them from scratch. If they’re a bit more clued onto it all the time, then it makes it easier for our staff to collate them and get them down.”*

However, many seasonal staff were very pessimistic about the public education program, as they did not believe it would help new skiers as most would likely ignore the posters. For example:

*“It’ll make, maybe somebody who’s curious and is waiting in the queue, and then looks ‘oh ya, this is a volcano, wow, ya, ok, that’s a lahar, ok’. I mean, ya it’s, it’s informative for someone who looks at the poster and decides to read it and study it, ya. But when the actual volcano, you know, something happens or if there’s an actual lahar or whatever, will it help that person react better knowing? No, I don’t think so.”*

It was mentioned that RAL is hoping to develop some site-specific signs around the ski area to inform customers in that area what their actions should be:

*“We’ll also be developing...a site specific sign for the Far West T-Bar which details, just, just brings to people’s attention, to customers out there ‘cause that is probably one of our high risk areas on a fine day, uh, where they are and what their emergency plans should be.”*

It is likely that the development of site-specific signs could have more of an effect on customers than posters placed around the ski area, because they will likely have more specific actions to follow. According to Morrissey and Reser (2000), public education materials which heighten the salience, nature, likelihood, and magnitude of a natural disaster and do not provide concrete information about what to do and how to deal with the situation can often result in a diminished response and preparedness motivation. Therefore, any new public education developed for the ski area should be limited in its explanation of the hazard, but be concise and direct on the appropriate actions.

#### **6.4 Observation of Simulation**

A simulation of the warning system response took place on Wednesday, August 3rd, 2005 at Whakapapa ski area. It was a fine day with no wind, with all areas of the ski area open, except the Far West area. Because it was the middle of the week, the ski area was not crowded. Staff were supposed to be informed by their supervisors in the morning before they began working that a lahar warning system simulation would be taking place, and the appropriate actions they should take. While this may have happened for the Lift Operations and Ski Patrol staff, most other staff were just notified by radio that the alarm system would be going off.

Observers were put into position at the following places on the ski area (Figure 5.3):

- Happy Valley
- Top of the Bruce
- Rockgarden
- Hutt Flat
- Waterfall Express Chair
- Knoll Ridge Café – Outside
- Knoll Ridge Café – Inside
- Knoll Ridge T-Bar – Loading area
- Knoll Ridge T-Bar – Offload area
- Waterfall T-Bar – Loading area
- Waterfall T-Bar – Offload area
- Valley T-Bar – Loading area
- Valley T-Bar – Offload area
- Far West area

This resulted in fairly good coverage of the ski area, with all lifts and main cafes being covered. The alarm was sounded just after 11am, for just over five minutes. The complete list of observations can be found in Appendix 4.

Staff in the Lower Mountain safe areas, such as Happy Valley, Top of the Bruce (including LBC) and Hutt Flat, all responded very well, and were seen offloading chairlifts and giving instructions and information to customers. Snow School Instructors in Happy Valley were very useful at helping skiers to move up towards the Happy Valley café. The only problem in the Lower Mountain was at the Rock Garden drive station, as Lift Operations staff were unable to hear the alarm. However, this is not a large concern as the Rock Garden is in a ‘safe area’.

Staff response on the Upper Mountain was varied. Staff at the Knoll Ridge, Waterfall, and Valley T-Bars all reacted appropriately. Of concern was the slow response time by staff, especially at the Waterfall T-Bar area which is next to a lahar path. The Lift Operator was unable to hear the alarm, and had a delayed response so the lift actually was not stopped until one minute after the alarm began ringing. Although customers on the T-Bar are not likely in danger, customers skiing generally do not tend to take the alarm seriously until they see the T-Bars stop moving, and even then there is a delayed reaction until the customers will head to higher ground. The sweep conducted by a Trail Safety member was also much too slow, as he/she did not enter the Waterfall T-Bar area until nearly three minutes after the alarm had sounded. There is also danger at the offload areas of all three T-Bars, as staff members are not generally present to instruct customers. Response at the Knoll Ridge café was very poor. Inside, café staff did not instruct or inform customers about what was happening. Outside, staff members also did not give any instructions to

customers. This is essential, as it is important for staff in safe areas such as Knoll Ridge Cafe to inform customers that they are safe and should remain in the building. Confused customers may begin to head down towards the car parks, which may put them at significant risk.

The Far West area was observed during this test to determine if the speakers were working as the area was not open to the public.

There were many lessons learned from this simulation. The first was the importance of a briefing amongst observers before the test for what is key to record, such as staff and customer response, as well as specific notes as to which speakers were working around them. The second was for staff to be debriefed after the test, so they could learn if the response they took was the correct one and make adjustments accordingly.

### **6.5 Observation of Blind Test**

The blind test of the warning system took place on Wednesday, October 12<sup>th</sup>, 2005 at Whakapapa ski area. Conditions on the ski area were near white-out, with very low visibility. However, the ski area was still crowded due to good snow conditions and many school groups being present. The Far West area was open, although a few lifts were shut down just before the alarm due to decreasing visibility. Happy Valley was closed due to minimal snow coverage, so the Hutt Flat area was very busy with beginner skiers. There was no wind present. The test was organized to be blind, so that staff would be unaware of the impending alarm. However, due to the presence of an increased number of DoC staff as well as a camera crew filming the test, it is likely that staff were tipped off that something unusual may be happening. Communication on the Ski Patrol radio was also observed, and about five minutes before the alarm a Ski Patrol staff member was heard asking if they should begin assigning sweep positions for the blind test.

There are many difficulties in regards to running a completely blind test on the ski area. In order to maintain good relationships between organizations, DoC managers generally inform several RAL managers (mountain manager, ski area manager, and Safety Services manager) about the upcoming test. The Customer Service manager is generally also informed so that observers are able to get lift tickets. While some staff remain unaware, staff that will have an important role for an actual volcanic event response are generally aware of the impending alarm. In the author's opinion, unless the second test can be truly blind, it is unnecessary to have a 'blind test' alarm every year, as it likely does not teach staff anything new and does not give observers an honest reaction of how

customers and staff would respond to a real alarm, and may also result in desensitization to the alarm system.

Observers were put into position at the following places on the ski area (Figure 5.4):

- Top of the Bruce
- Rockgarden
- Hutt Flat
- Waterfall Express Chair
- Knoll Ridge Café – Outside
- Knoll Ridge Café – Inside
- Knoll Ridge T-Bar – Loading area
- Knoll Ridge T-Bar – Offload area
- Waterfall T-Bar – Loading area
- Waterfall T-Bar – Offload area
- Valley T-Bar – Loading area
- Valley T-Bar – Offload area
- Far West area – Top
- Far West area – Bottom

This resulted in fairly good coverage of the ski area, with all lifts and main cafes being covered. The alarm was sounded just after 11am, for just under three minutes. The complete list of observations can be found in Appendix 5.

Response on the Lower Mountain was mixed. Staff at the Top of the Bruce seemed to respond well, particularly LBC Food and Beverage staff, Road Service staff, and Customer Service staff. Rental staff could have been more informative to the customers they were serving. Staff at Hutt Flat also responded well, although needed to respond much quicker as reactions were very delayed. Snow School Instructors were very informative to staff, and Lift Operation staff acted fairly appropriately. The overall trend in the Lower Mountain area was that customers wanted more information.

Response on the Upper Mountain was also mixed. Again, there was no response from Knoll Ridge café staff, likely because they could not hear the alarm inside the building. Staff outside the Knoll Ridge café had a better response, with Snow School Instructors giving instructions to customers. It was also found that the Lift Operator at the Waterfall Express offload area was very busy, and would likely benefit from help from another staff member. Staff working on and around the three T-Bars had fairly good responses, but once again were much too delayed. The Ski Patrol sweep by the Waterfall T-Bar took too long, with the Ski Patroller arriving at the bottom of the area four minutes after the alarm.

The Far West area was also observed during this test. Staff were reported to have a very good reaction in most areas. There seemed to be a high number of Ski Patrollers in this area who gave appropriate directions to customers. Lift Operations staff also responded well by giving direct instructions to customers about what was happening and where to proceed to. Food and Beverage staff at the West Ridge café seemed unsure of what to do.

Therefore, it seems that staff response to this blind test was adequate, although the reaction time of staff and customers must be improved in all areas of the ski area.



## Chapter Seven

# Further Discussion and Recommendations

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This chapter discusses key themes that relate to the initial objectives of the study; it builds on the result-specific discussion given in Chapter Six. Constraints to organisational commitment to disaster planning are discussed, as is RAL's legal obligations to provide volcanic hazard training for their staff. A training needs analysis for the ski areas is also presented, broken down departmentally. Recommendations for Whakapapa and Turoa ski areas are then brought forth and discussed.

## 7 FURTHER DISCUSSION AND RECOMMENDATIONS

### 7.1 Common Organisational Constraints

There are several factors that can constrain organisational commitment to disaster/crisis planning. Paton (1996a) acknowledges the following:

- Underestimation of risk
- Underestimating the consequences for employees and organisations
- Overestimating existing (response) capabilities
- Competition with other (mainstream) activities for limited resources
- Difficulty substantiating the benefits
- Ambiguity of responsibility

This model can be applied to RAL and their commitment to preparing for a volcanic event.

### *7.1.1 Underestimation of risk*

In all of the research conducted for this study, underestimation of risk was found to be a common theme in almost all staff responses. As shown by the data, staff displayed an optimistic opinion of what was likely to happen on the day and generally showed an attitude of personal invulnerability. Staff working in safe areas, such as Food and Beverage staff and Rental staff, were most likely to display these characteristics. However, there is nothing to say that a volcanic event affecting the ski area will not be complicated and difficult to handle. If a 100-year frequency event (see Section 2.2.4) were to hit during a fine Saturday at the ski area, the effects of an eruption would be incredibly complex and the impact extremely serious (refer to Sections 3.3 and 3.4). Even if a smaller event were to occur, the response would still be an incredibly complex and high stress situation, and require help from all RAL staff members. The biggest danger of underestimation of risk is that it generally leads to unpreparedness (McClure and Williams, 1996), which in this study would result in the ski area company feeling it is unnecessary to properly train staff and to develop an effective volcanic event response plan.

There are many different factors that influence how risk is perceived. Paton and Sylvester (1996) reason that differences in such variables as life experience, emotional maturity, and cognitive sophistication will work together to influence how problems are defined, or in other words, the mental model one will develop about the risk of volcanic hazards at the ski area. Specific factors that may contribute to the development of one's mental model of volcanic risk at the ski area include experience working at ski areas and familiarity with volcanic eruptions. See Section 7.3.1 for a more detailed discussion on mental models.

### *7.1.2 Underestimating the consequences for employees and organisations*

Another factor that was recurrent throughout the data was the underestimation of the possible consequences for employees and organisations of a volcanic event at the ski area. Staff were optimistic about the consequences of a volcanic event, including the psychological outcome (Section 6.3.9), which again displays the theme of personal invulnerability. Limited mention was made of possible consequences to the company. However, it is possible that if enough damage is done to the ski area facilities or if the response effort is handled improperly, the ski area may never be able to reopen due to either legal or monetary reasons. An example of this is the sale of the Turoa ski area to RAL by its former company after not being able to recover monetarily from the 1995/96 eruptions. Also, if customers or staff are killed or injured by a volcanic event, RAL could



be held liable, particularly if it appears they were negligent about their preparation to handle a volcanic event. See Section 7.2 for a more detailed discussion.

### *7.1.3 Overestimating existing (response) capabilities*

Overestimating the company's response capabilities was also found to be a common theme in the data. As shown in Sections 6.2.6, 6.3.5, and 6.3.8, staff are confident that RAL will be able to handle a volcanic eruption and most are also confident in their personal ability to respond appropriately. Many staff also frequently referred to the 'plan'; however the author was unable to find out if such a plan did in fact exist. The presumed existence of an effective response plan can be dangerous, as it often lulls personnel and management into a false sense of security (Paton, 1996a). This was proved at Whakapapa ski area, as those who were found to make reference to 'the plan' were also likely to be optimistic about the response. It is also likely that new staff will have a more positive view of the company's response capabilities, which was also proved by this study, as new seasonal staff had a much more optimistic view than permanent staff.

### *7.1.4 Competition with other 'mainstream' activities for limited resources*

This factor is of particular relevance to RAL. There are many everyday hazards on the ski area that are of concern to the company, such as cliffs and rocks. Also of concern are other hazards such as blizzards, avalanches, ice, environmental conditions (i.e. cold) and white-outs. It was determined that the amount of input the company makes regarding a certain hazard is determined by frequency and severity (see section 6.3.1). The company assigns others hazards a much higher frequency standing than lahars or volcanic events, even though the potential severity of a volcanic event might be equal or more than a different hazard. Therefore, this competition with more 'threatening' hazards tends to lead to the limited emphasis RAL puts on volcanic hazards in relation to others. The goal then in volcanic hazard training is for RAL to develop a concise, informative, specific training program in the time they allow for lahar hazard training, and to further train staff on handling emergency situations which focus on other 'more likely' hazards.

Another area that suffers from competition with other activities is training staff who join RAL mid-season in regards to volcanic hazards. It is likely RAL will need these staff to begin work immediately and managers may not be able to take time to administer the safety course. This is a difficult situation for the company, as it is understandable that new staff join throughout the winter season and it is difficult to train each person in the response to a volcanic event. The best way to

solve this is through incorporation of this issue into the culture of the organisation and its transmission through organizational socialization process (i.e. talking about it regularly with other staff) (Paton, 1999). Organisational commitment to the program, which can be accomplished by key ski area personnel taking the issues seriously and reflecting this to other staff members, is necessary to incorporate volcanic hazards risk into the organisation (see Section 6.3.8).

#### *7.1.5 Difficulty substantiating the benefits*

A common theme in many of the interviews with staff member was the feeling that how a person would respond to a lahar warning and cope after an actual event was very individual. While this is a correct inference, as people respond differently to emergency situations, a few staff members used this belief to suggest that lahar training was only beneficial to a point (see Sections 6.3.2 and 6.3.9). These staff felt that it was necessary to learn about the hazards and to have support systems available to staff, but felt it was unnecessary for staff to receive training on emotions they may experience during and after an event. However, it has been found that coping issues relating to stress and trauma can be managed proactively using stress resilience training (Paton and Flin, 1999; Paton and Jackson, 2002). If a person can anticipate feeling he or she may develop, it helps to reduce post-traumatic stress as the person is able to then recognize and manage these emotions (Morrissey and Reser, 2003). It is also noted by Spillan and Hough (2003) that many businesses assume they will not be affected by crises, yet this assumption is overly optimistic and a formula for an ineffective response to an eventual crisis.

#### *7.1.6 Ambiguity of responsibility*

A dilemma facing RAL's commitment to planning for a volcanic event is ambiguity of responsibility. Because Ruapehu is in a national park, DoC is in control of the area and RAL is a concessionaire, which means they pay DoC a certain yearly fee to be able to operate on the mountain. Therefore, there is mixed opinion as to how much of the response effort RAL will be responsible for. However, in order to plan for a worst case scenario, it is important for RAL to realize that it is possible they will be isolated and therefore solely responsible for getting all customers on the mountain to safety. Joint and inter-agency training/preparation is also important to ensure that issues are not missed because one agency assumes the other is responsible and has done something, as well as to help build understanding of their separate contributions to response and recovery management.

## 7.2 Legal Requirements for RAL

RAL is required legally to provide volcanic hazard training to their staff due to two main reasons. The Health and Safety in Employment Act (Department of Labour, 2002) is the first reason, as there are numerous requirements made in the Act for employers. The object of the Act (Section 5) is to:

- encourage the prevention of harm to all persons at or in the vicinity or a work place by promoting excellence in health and safety management,
- define hazards or harm in a wide-ranging way,
- impose persons who are responsible for work with various duties,
- set requirements that are flexible to cover different circumstances, and
- recognize that successful management is also achieved through the input of those doing the work.

There are certain requirements an employer also must meet, which are specified in Section 6 of the Act. Those that relate to RAL and volcanic hazards are as follows:

- Provide and maintain a safe working environment for employees, and
- Develop procedures for dealing with emergencies that may arise when employees are at work.

Section 16 of the Act also stipulates that those who control a place of work must also take practicable steps to ensure that no hazard that is or arises in the workplace harms people in the vicinity of the area (including people in the vicinity solely for the purpose of recreation or leisure).

The Act also stresses the three step process of either eliminating, isolating, or minimizing hazards, which is the same system that RAL uses in handling ski area hazards. Because the volcanic hazards at Ruapehu can neither be eliminated nor isolated, Section 10.2 of the Act requires that steps must be taken to minimise the likelihood that the hazard will be a cause or source of harm to employees.

Of particular relevance to RAL is that Section 12 of the Act stipulates that employees must be informed of the hazard and provided with ready access to information about the hazard which the employee is likely to understand. At RAL, many employees are likely to be completely unaware when they first arrive at the mountain that there is an increased risk at the ski area from volcanic eruptions and that there is a set procedure they will need to be a part of in response to a volcanic event. The Act specifies that information must be provided about:

- What to do if an emergency arises while the employee is working,
- All identified hazards to which the employee may be exposed to while working, and
- The steps to be taken to minimise the likelihood the hazards will be a cause of a source of harm to the employee

RAL is also obligated to provide volcanic hazard training to their staff due to the concession agreement between DoC and RAL. Because Whakapapa and Turoa ski areas are in a national park, DoC agrees to let RAL operate in the national park as a concessionaire. RAL then has certain obligations they must fulfil, which are contained in the concession agreement. Because of the commercial sensitivity of the agreement, the author was not able to be granted access to view the volcanic hazard section. However, it is understood that RAL is obligated to provide their staff with volcanic hazard training and to be prepared to handle a volcanic eruption (Graham Leonard, *personal communication*, 2005).

### 7.3 Key findings

The following findings correlate to the objectives in Section 1.2.

#### 7.3.1 *Staff perception of the risks of volcanic hazards on the ski areas*

It was assumed at the commencement of this study that staff, especially seasonally-employed staff, would be unaware of the volcanic hazards at Ruapehu, and therefore would have a low risk perception of the volcanic hazards at the ski area. However, it was found that most staff are very aware of the different volcanic hazards at Ruapehu (Sections 6.2.2, 6.2.4, 6.2.8, and 6.3.3) yet risk perceptions encountered varied greatly. Some staff were very worried about handling a volcanic event and the hazards that may occur, while other staff were very confident and thought it would be easy to keep customers safe and evacuate the ski area quickly. Generally permanent staff were more worried about the volcanic hazards and response, and seasonal staff were found to be much more confident. It is a common reaction for people to be confident, as most view themselves as personally immune to hazards (Slovic et al., 1980).

It is quite common for a group of individuals dealing with the same hazard to have very different risk perceptions (Paton et al., 2001). It has been found that differences in life experience, emotional maturity, and cognitive sophistication all play into how a problem is defined (Paton and Sylvester, 1996). These are used to generate a mental model of a hazard, which can be described as the set of principles from which one generates predictions or ideas about a situation (Bostrom et al., 1992).

Gregory et al. (1997) indicates several factors that influence one's mental model:

“Individual's perceptions are likely to have geographical, social, economic, cultural, and temporal components, and include, consciously or subconsciously, factors such as the magnitude of the hazard, the cost and availability of alternatives, the degree of perceived control over the consequences, the degree of personal exposure, and other social costs and benefits” (p. 48).

Generally, when faced with uncertainty and complexity (which is expected when dealing with the response to a natural hazard), people use various methods to try to simplify their understanding of complex processes and relationships (Spedden, 1998). These may include:

- Using decision rules, which are based on intuition and past experience,
- Constructing mental models, and
- Relying on outside sources of expertise (real or perceived).

The mental models that people use to make sense of hazardous processes generally affect how the risk is perceived, and the cognitive, emotional, and behavioural efforts people make to deal with these situations will be shaped by their mental model (Spedden, 1998).

It is also common for lay people's mental models of hazards to differ greatly from expert perceptions of the hazards (Gregory et al., 1997; Bostrom et al., 1992), which may lead to important misunderstandings about the hazard. An example of this that was seen frequently in the interviews was the perception amongst staff of how a lahar would act. Some staff made reference to it being high enough to wash customers out of the chairlifts, and therefore believed the correct response should be to evacuate the chairlifts immediately instead of running them out. Other staff thought that a lahar would be hot and had the potential to burn them and other structures in the lahar's path. If management staff leading the lahar hazard training session are unaware of these misconceptions, it is very difficult for them to correct them. Staff also seemed very unaware of how fast a lahar can move and how short the warning time is between the warning system activating and the lahar entering the ski area. If staff were more aware of this, it is likely their risk perceptions would be quite different.

It was also found by Gregory et al. (1997) that individuals are prepared to tolerate risks in certain circumstances, in return for benefits the circumstances may offer. Slovic (1987) found that the public will accept risks from activities such as skiing that are 1000 times as much as they would tolerate from involuntary hazards. This was also referred to by staff at RAL, with one staff member describing:

*“like people don't, they don't care {about the volcanic hazards} as long as they've got some good skiing around”*

It is important for risk perception of volcanic hazards by staff on the ski area to be high, as those who perceive they are vulnerable are generally more likely to respond to warnings and undertake protective behaviour (Johnston et al., 1999a). The difficulty on the ski area lies in convincing staff that the risk of a volcanic event affecting the ski area is fairly high, but that certain activities can lower the risk to themselves and to customers. A major barrier to this is the personal invulnerability

displayed by staff members throughout the interviews, who repeatedly pointed out that other people may die but did not indicate they would suffer the same fate (Sections 6.3.3 and 6.3.9). Other staff also felt a 'blue-sky' eruption would be unlikely, therefore the risk to them would be low as they would likely not be on the ski area if it was going to erupt (Section 6.3.3).

In conclusion, it was found that staff were knowledgeable about the volcanic hazards at the ski area, including lahars, but had differing perceptions of the risk associated with these hazards. This shows the different mental models that staff members have of a potential volcanic event.

### *7.3.2 Staff knowledge of procedures for the response to a volcanic event, particularly the evacuation stage (Stage 2)*

It was found in this study that staff were very knowledgeable about the initial response (Stage 1) actions they would be required to take during a volcanic event (Section 6.3.6). This is positive, as staff have similar mental models of the immediate response to the warning system. Staff will likely have high self-efficacy for this part of the response, which is defined as an individual's judgement regarding their capabilities to execute courses of action required to achieve objectives (Bandura, 1997). This is important, as irrespective of the level of perceived risk, it was found by Paton et al. (2001) that people are unlikely to prepare for a hazard event if they perceive the effects as insurmountable or if they do not think they have the competence to act. Therefore, having staff knowledgeable and confident of the initial response (Stage 1) actions will provide for outcome expectancies which support the intentions to promote resilience and facilitate personal acceptance of responsibility (Paton, 2001).

On the other hand, opinions were very mixed on what would happen after Stage 1 of the response passed, and the response entered the evacuation stage (Section 6.3.7). The amount of confusion that surrounds the Stage 2 evacuation is worrying, particularly amongst permanent staff members who others will look to for directions. Staff were unsure of how long it would take to evacuate the ski area and how many people would likely need to be evacuated. Ski Patrol indicated there was a broad evacuation plan for the ski area; however, there would be problems with applying this during a volcanic event as areas may be isolated by lahar paths and ash fall and damage may be done to ski area facilities (such as lifts) needed in the evacuation. Galley et al. (2003) suggested that the ski area consider evacuation routes in advance, and then pick the best route from each threatened area to include in the evacuation plan. However, it is important to have multiple evacuation routes listed in the eruption response plan, in case the 'best option' is blocked. It is concerning that staff are so

unsure about the Stage 2 response effort because it is possible if staff do not receive immediate instructions they will take the course of action which they feel will lead to safety, such as trying to get off the ski area by crossing a lahar path. The assumptions that staff make about an evacuation may also be very different from the plan that RAL management wants to initiate. Paton (2003) describes that during the response phase of an emergency situation “inappropriate assumptions regarding operating conditions, performance expectations, roles, and tasks significantly increase stress vulnerability” (p. 205).

In conclusion, it was found that staff are knowledgeable and confident in the initial (Stage 1) response to a volcanic event on the ski area. However, they were very unsure of what the evacuation or Stage 2 response would involve. This can be fairly easily corrected by briefly discussing a ski area evacuation in induction training (which will be discussed in Section 7.5).

### *7.3.3 A practical system of effective training session and simulations designed to mitigate the risk*

In the 2005 winter season, RAL adopted some of the recommendations put forth by Ward et al. (2003) and Leonard et al. (2004). These recommendations included:

- separating departments for the lahar hazard training to receive role specific information,
- evaluating training by getting staff to fill out a question sheet, and
- conducting a yearly alarm simulation, followed by a later season blind test

Permanent staff members commented during the interviews that most feel that the lahar hazard training has improved at the ski area since last year.

Allowing time for staff training on lahar hazards during staff induction week is difficult, as staff are also required to learn their daily jobs and how to handle other hazards on the mountain. Therefore, it is important for the lahar hazard training to be concise and clear, covering all the major issues in the shortest amount of time possible. Major issues that need to be covered include the volcanic hazards at Ruapehu, eruptive history, impacts of lahars, safe areas and lahar paths, the warning system, and role specific response information. However, because staff will be handling a stressful emergency situation, it is also necessary for training to cover developing realistic expectations about personal vulnerability and how the event will play out, promote the use of coping strategies, and discuss the post-event support available to staff and the benefit of using these (Paton, 1996a). Discussing the event in detail will help staff to develop similar mental models of the response, leading to a more efficient performance (Paton and Jackson, 2002), and will likely lessen negative reactions that may occur, if staff are uncertain about the duration of the disaster, the period of their

involvement, or about additional threats (Paton, 2003). Training will also play a pivotal role in managing stress reactions (Paton and Flin, 1999), as identifying potential stressors during the response and areas that they may occur in during training, as well as reinforcing this in training simulations, will help to minimize their dysfunctional consequences (Paton, 1996b).

Recommendations to improve training at the ski areas can be found in Section 7.5.

It is commonly indicated that simulation exercises are invaluable as to the level of training they provide to those participating in them. Paton and Jackson (2002) give several positives associated with conducting simulation exercises:

1. Afford opportunities to develop, review, and rehearse under realistic circumstances,
2. Practice dealing with high pressure situations in an environment that is safe and supportive,
3. Practice the roles they will adopt in a disaster situation,
4. Receive feedback on their performance and identify areas of personal development,
5. Increase awareness of stress reactions and facilitate rehearsal of ways to minimize negative reactions, and
6. Identify organizational constraints on effective response management.

In its current simulation format, RAL is accomplishing objectives 2 and 3: however the others remain elusive. It is important after a simulation exercise for managers and supervisors at the ski area to give feedback to staff (objective 4) so that they will either become confident that they know the correct response or be informed of the correct actions. It would also be beneficial for the management staff at RAL to be informed, either by area managers and supervisors or by the simulation test observers, of the actions on different areas of the ski area so they can determine what the overall response was and what areas need improvement. An example of this has been the continuing negative performance during the simulations and blind test of the last few years of the Food and Beverage staff, who continually do not react to the warning system. While the reason for this may be as simple as the staff in cafes not being able to hear the warning system, coming up with a solution to the problem is impossible if no one knows what the recurring problems are.

Recommendations in regards to improving the simulations can be found in Section 7.5.

In summary, it was found that RAL has made huge improvements to their lahar hazard training program over the past few years, based on recommendations by Ward et al. (2003) and Leonard et al. (2004). However, there are still changes to be made that will benefit the staff training and simulation exercises, without lengthening the time needed for training, which are discussed in Section 7.5.



It is also necessary to avoid ‘risk homeostasis’ at the ski area, which occurs when a perceived increase in safety may possibly reduce the risk perception of that hazard, and may encourage unsafe behaviour (Johnston et al., 1999b).

#### *7.3.4 A realistic volcanic hazard response plan for the ski area using a CIMS structure*

Currently, there is no specific ski area plan for handling a volcanic event. During the interviews, it was discovered that the plan for RAL management was to apply a broad evacuation plan for the Stage 2 part of the response effort. However, this is likely to be impractical, as a volcanic event is a unique event and quite dissimilar to any other kind of hazard the ski area may face. Disaster planning is not only beneficial due to the output of a ‘plan’ to help guide the response effort, but it also helps those who engage in the planning activities to develop similar mental models of the event and response which will be beneficial during an actual event (Paton and Jackson, 2002). The plan should be based upon a detailed and comprehensive analysis of operational demands (similar to Section 7.4), and an inventory of potential disaster stressors (similar to Section 6.2.9 and 6.3.9), linked to actions such as training and simulation exercises, and test regularly (Paton and Jackson, 2002; Paton and Flin, 1999). It was found that staff are very open to having a specific volcanic event plan, as most either already thought RAL had one or were in support of developing one.

It is also important for the plan to make note of the need to suspend organisational authority in favour of lower level decision making in the early stages of the response (Galley et al., 2003). Authority can then gradually be transferred back to head management staff after Stage 1 (initial response) has passed (Paton, 1997). The overall evacuation plan must also be decided, with the option of flexibility, as certain evacuation routes may be impassable after a volcanic event. It is also necessary to decide if the evacuation will be done group by group, with groups being specifically instructed when to move or whether all groups will be given permission to move at the same time (Galley et al., 2003). Staff must be informed during lahar hazard training of what the decision is so that they know what to expect during the response to a volcanic event.

RAL has also recently shown an interest in using CIMS during the response to a volcanic event. Although this may be beneficial as a CIMS structure will provide RAL the flexibility that will be needed to handle a volcanic event, there are several reasons why using CIMS during a volcanic event would not currently be beneficial for RAL. The first is that only a few key management staff at RAL are aware of CIMS. It was found during the staff interviews that only three out of twenty-six staff knew what CIMS was. In order for CIMS to work, it is important for all management staff

to be aware of it so it can be quickly implemented during an emergency event with minimal confusion. CIMS is also fundamentally about working together, rather than simply describing how people should work together. In CIMS, top-down organisational structure is used. However, as discussed previously (Section 4.1.1, as well as in the previous paragraph), it is more likely during a ski area response to a volcanic event that organisational authority will likely be suspended in favour of lower-level decision making (Galley et al, 2003; Paton, 1997). Also, integrated communication is stressed in CIMS, but it is more likely that information management (which is separate from communication) will be more crucial to the ski area during the response effort. Information management involves identifying what is communicated and whether it is meaningful to recipients (Paton and Hannan, 2004). CIMS also requires that an Initial Action Plan (IAP) be drafted before an event. However, this plan would involve including response goals, operational objectives, and support activities, which are unimportant for a ski area event as the goals and objectives are obvious.

In summary, it is important for RAL to draft a plan for how they will deal with a volcanic event. Thinking through how they will handle a volcanic event will increase the company's resilience, which is defined as "the capacity of systems to main their integrity and the relationships and balance between elements in the presence of significant disturbances by drawing upon internal resources and competencies to manage the demands, challenges, and changes encountered" (Paton et al., 2001, p.47). This resilience will decrease the reliance of RAL on DoC, as it is important for the ski area to plan for a worst case scenario where they will be isolated from outside help. A CIMS structure could be effective at the ski area, however staff members need to be aware of CIMS and how to implement it, and an initial action plan (IAP) must be drafted. To be successful, the plan requires support from all levels of management, most important being senior management (Clark, 1996).

#### **7.4 Training needs analysis**

In preparation for managing a potential crisis, training needs analyses become very important. It is vital for a training needs analysis to identify situations that may be encountered when responding to a disaster, and the demand characteristics and competencies likely to be used (Paton, 1999). Paton (1999) notes that "information obtained can be useful to assist plan development, defining the training and support needs of staff, and to develop systems and procedures that promote organisational resilience" (p.132). The comprehensive inventory of disaster stressors from Sections

6.29 and 6.39 were used when developing the training needs analysis to help identify high risk situations and to provide a basis for anticipating the intensity of reactions to these stressors (Paton, 1996b). These potential stressors can also alert RAL to the likely support requirements that will need to be met (Paton, 1996b).

Galley et al. (2003) suggests people will function better during an emergency if they know what to do in advance, but stresses that this does not mean developing a long list of details of individual actions. A clear role description should be provided, based on the development of general competencies (Paton, 1996b; Paton and Jackson, 2002), which allows individuals to use common sense to carry out the role. The following training needs analysis for Whakapapa and Turoa ski areas (Tables 8 to 16) attempts accomplish this. This table was expanded from the original training needs analysis from Ward et al. (2003) (Tables 6 and 7). The head of the response effort is referred to in the training needs analysis as the Incident Controller (IC). There are slight differences as to how the training needs analysis should be applied to each area, which are explained in the sections below.

#### *7.4.1 Whakapapa*

At Whakapapa ski area, the main hazard is from lahars. Therefore, the biggest problems encountered after the Stage 1 (initial) response will be moving groups of customers off the ski area, as routes down the mountain may be blocked by lahar paths, and chairlifts that were needed for the evacuation may be wiped out. Because of the distance from the Summit Hazard Zone, it is likely that these initial lahars are the biggest danger to the ski area and once these have passed, time can be taken to make sure customers and staff are not crossing lahar paths and also to assess the danger of secondary flows which will likely be done by GNS and DoC.

#### *7.4.2 Turoa*

At Turoa, it is uncertain whether lahars or ballistic bombs will be the larger threat to the ski area (Figure 7.1). At the present time, research is being conducted by GNS to determine the likelihood of lahars passing through the ski area during an eruption event. If the largest hazard is determined to be ballistic bombs in the summit hazard zone, it is therefore important that customers and staff in the Summit Hazard Zone are evacuated immediately to reduce the risk from ballistic bombs.

Customers and staff in this area may be evacuated to the Giant Café, at the top of the Giant Chair and at the base of the High Noon T-Bar, and remain there until it is determined to be safe to get down the mountain.

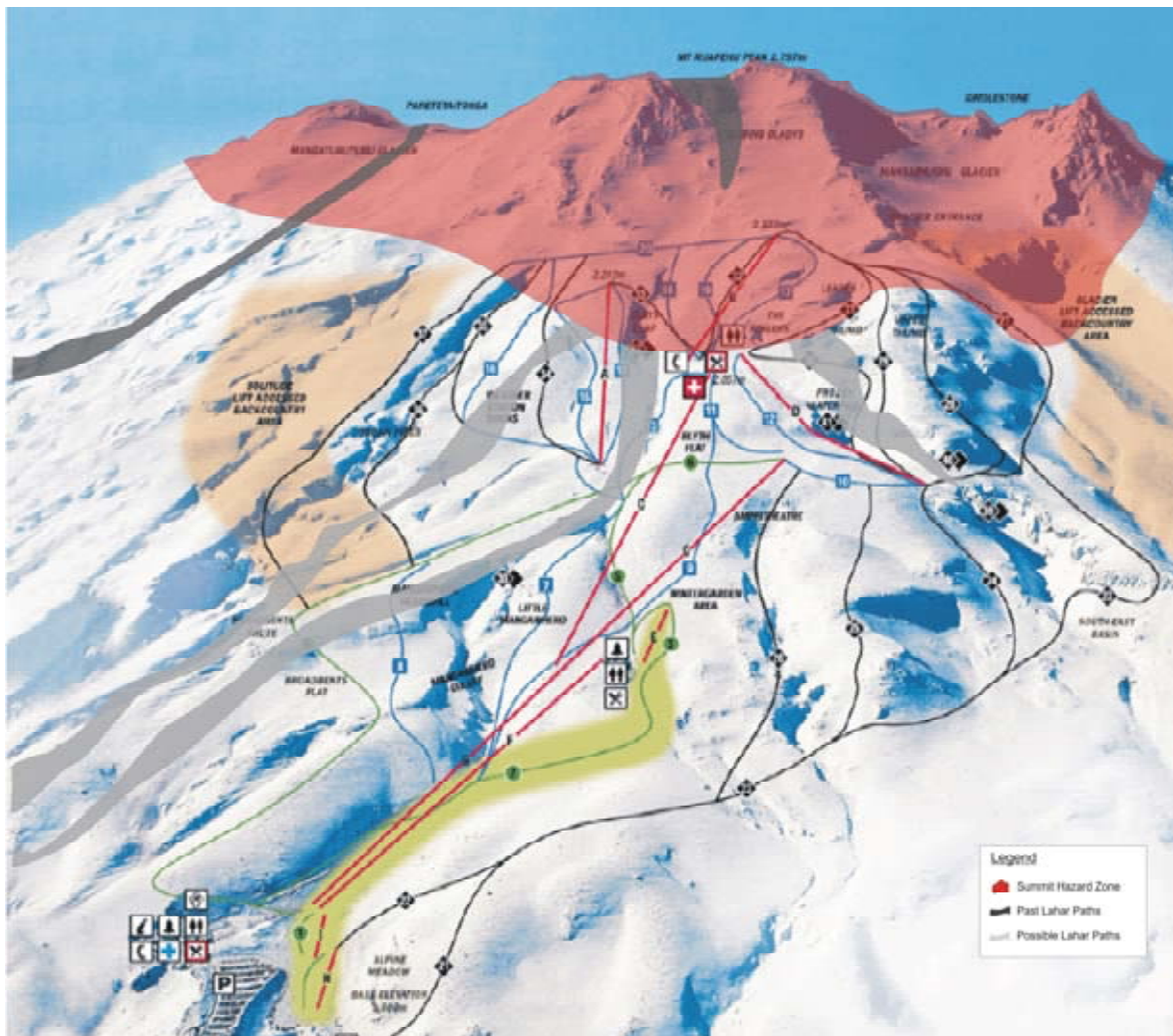


Figure 7.1 Hazards at Turoa ski area

Table 7.1 Training Needs Analysis for Ski Patrol

	Daily Tasks	Training Needs	Volcanic Event response tasks			Training Needs	Suggestions
			Pre-Event	Stage 1 – Initial response	Stage 2 - Evacuation		
<b>Ski Patrol</b>	<ul style="list-style-type: none"> <li>- Prepare ski area for the day (includes trail checks, setting out fencing, signs, etc)</li> <li>- Consult terrain hazard atlas to manage hazards</li> <li>- Avalanche control work if it is necessary</li> <li>- Communicate with other departments to open the ski area</li> <li>- Help customers and staff who have been in accidents, injuries</li> <li>- Shut the ski area down by conducting sweeps and pulling in signs</li> <li>- Possibly work in RARO (Ruapehu Alpine Rescue Organization) in search and rescue tasks</li> </ul>	<ul style="list-style-type: none"> <li>- Medical skills</li> <li>- Search and Rescue skills</li> <li>- Ski area and terrain hazard atlas knowledge</li> <li>- Avalanche control training</li> <li>- Customer service skills</li> <li>- Open and closing procedures</li> <li>- Accident reporting procedure</li> </ul>	<ul style="list-style-type: none"> <li>- Provide information to customers and staff enquiring about the volcanic hazards at Ruapehu</li> <li>- Be positive role models for other staff members by treating the hazard as worthy of concern, and by treating each test of the warning system seriously</li> </ul>	<ul style="list-style-type: none"> <li>- <b>Sweep of high risk areas</b> if in position, otherwise help customers and staff in your area to move to high ground</li> <li>- <b>If near T-Bar offload area, help customers there</b></li> <li>- Move to higher ground with customers and assure they remain there, reassure them of their safety</li> </ul>	<ul style="list-style-type: none"> <li>- Attend to those injured</li> <li>- Wait for instructions on radio channel, do not move customers until authorized to do so by the head Ski Patroller, the ski area manager, or the Incident Controller, and then move customers to where you are requested to go</li> <li>- <b>Ski Patrol members may be asked to take control of a sub-area</b>, which will involving giving instructions and information to customers and staff members in that area</li> </ul>	<ul style="list-style-type: none"> <li>- General information about the volcanic hazards at Ruapehu, eruption history, and frequency of events.</li> <li>- Information about lahars, how they flow, lahar paths at the ski area, and safe areas</li> <li>- Information on the summit hazard zone at the ski area</li> <li>- Information about the warning system and warning times</li> <li>- Information on the correct response actions</li> <li>- Information on the evacuation plan, and the importance of remaining in safe area until authorized to move</li> <li>- Information on the development of realistic expectations of personal vulnerability</li> <li>- Information on different types of coping strategies and services that will be offered to staff, and the benefits of using them</li> </ul>	<ul style="list-style-type: none"> <li>- When explaining hazards and past eruptions, indicate what it means for contingent decision making and response, as well as using this information to develop stress resilience</li> <li>- Evacuation plan can be included in the general Health and Safety as the general evacuation procedure</li> <li>- Can reference similarity of lahar movement to avalanche to put it into context</li> <li>- Medical skills will be taught in daily job training</li> <li>- Coping strategies and services can be beneficial to learn for all emergency situations at the ski area</li> </ul>
<b>Ski Patrol Manager</b>	Similar to above	Similar to above	Similar to above	<ul style="list-style-type: none"> <li>- Assign sweep positions, find locations of Ski Patrol members</li> <li>- Immediately communicate with Ski Area Manager on situation</li> </ul>	<ul style="list-style-type: none"> <li>- Decide along with Field Operations Manager and Ski Area Manager on who will be assigned CIMS positions (if needed), including the Incident Controller (IC) position</li> <li>- IC should begin communicating with DoC and GNS <b>on the status of the volcano</b></li> <li>- Assign Ski Patrol members to different sub-areas</li> <li>- Assign where First Aid Centres should be set up and who should staff them</li> <li>- When approved, <b>initiate ski area evacuation plan</b></li> <li>- After field has been evacuated, coordinate with DoC to form search and rescue groups, if needed</li> </ul>	Same as above, but including: <ul style="list-style-type: none"> <li>- CIMS structure (if needed)</li> <li>- Communication procedures with DoC and GNS</li> <li>- Sub areas of ski area</li> <li>- Evacuation procedure</li> <li>- Information and decision management (Paton and Hannan, 2004)</li> </ul>	Similar to above

Table 7.2 Training Needs Analysis for Lift Operations

			Volcanic Event response tasks				
			Pre-Event	Stage 1 – Initial Response	Stage 2 – Evacuation		
	Daily Tasks	Training Needs				Training Needs	Suggestions
Lift Operations	<ul style="list-style-type: none"> <li>- De-ice towers (only some lift operators)</li> <li>- Report in, get lift assignments</li> <li>- Perform safety checks on lift and set up for the day (can include shovelling snow, preparing on-load and offload areas, setting up queue lanes)</li> <li>- Load and unload customers, help beginners</li> <li>- Answer customer questions and make sure they are dressed for the weather conditions</li> </ul>	<ul style="list-style-type: none"> <li>- General customer service</li> <li>- Lift operations training (location and types of lifts, safety procedures, loading technique, loading disabled customers)</li> <li>- Chair lift evacuations</li> <li>- Job safety, ski area hazards</li> <li>- Radio training</li> </ul>	<ul style="list-style-type: none"> <li>- Provide information to customers and staff enquiring about the volcanic hazards at Ruapehu</li> <li>- Be positive role models for other staff members by treating the hazard as worthy of concern, and by treating each test of the warning system seriously</li> </ul>	<p>Chairlifts</p> <ul style="list-style-type: none"> <li>- <b>Stop loading customers, speed up chairlifts, call last number (last chairlift loaded) to lift operator at offload area</b></li> <li>- While chairlift is emptying, direct staff in area to higher ground (safe areas)</li> <li>- Lift operators in offload area should help customers off lift, direct to safe area</li> <li>- Chairlift should be stopped once it is emptied and lift operators should move to safe area</li> </ul> <p>T-Bars</p> <ul style="list-style-type: none"> <li>- <b>Immediately stop T-Bar once the alarm is heard</b></li> <li>- Instruct and help customers in area to safe zone</li> <li>- Lift Operators should remain with customers in safe area, keep customers in area, and reassure them of their safety</li> </ul>	<ul style="list-style-type: none"> <li>- Attend to those injured and keep customers warm and in safe zone</li> <li>- <b>Wait for instructions</b> on radio channel, do not move customers until authorized to do so by the head Ski Patroller, the ski area manager, or the Incident Controller, and then move customers to where you are requested to go</li> <li>- Provide information over radio as requested, <b>do not overload radio channels asking for instructions</b></li> </ul>	<ul style="list-style-type: none"> <li>- General information about the volcanic hazards at Ruapehu, eruption history, and frequency of events</li> <li>- Information about lahars, how they flow, lahar paths at the ski area, and safe areas</li> <li>- Information on the summit hazard zone at the ski area</li> <li>- Information about the warning system and warning times</li> <li>- Information on the correct response actions, focusing on different response actions between chairlifts and T-Bars</li> <li>- Information on the evacuation plan, and the importance of remaining in safe area until authorized to move</li> <li>- Information on the development of realistic expectations of personal vulnerability</li> <li>- Information on different types of coping strategies and services that will be offered to staff, and the benefits of using them</li> </ul>	<ul style="list-style-type: none"> <li>- When explaining hazards and past eruptions, indicate what it means for contingent decision making and response, as well as using this information to develop stress resilience</li> <li>- Evacuation plan can be included in the general Health and Safety as the general evacuation procedure</li> <li>- Can reference similarity of lahar movement to avalanche to put it into context</li> <li>- Important to stress that chairlift does not need to be evacuated, it just needs to be sped up and run out</li> <li>- Coping strategies and services can be beneficial to learn for all emergency situations at the ski area</li> </ul>
Lift Operations Managers/ Supervisors	Similar to above	Similar to above	Similar to above	<ul style="list-style-type: none"> <li>- Immediately inform staff by radio that the warning system has been activated and to take the appropriate response actions</li> <li>- Coordinate with other supervisors and managers as to their location on the ski area</li> </ul>	<ul style="list-style-type: none"> <li>- Notify IC of status and location when requested, prepare to take possible role in CIMS structure</li> <li>- Reassure Lift Operations staff by radio to remain where they are, keep customers together, and to being collecting names of those with them (if they are able to do so)</li> <li>- Assist IC with evacuation of ski area</li> <li>- Pass names collected by staff on to Customer Services</li> <li>- Take instructions from IC on assisting with search and rescue</li> </ul>	<p>Same as above, but including:</p> <ul style="list-style-type: none"> <li>- CIMS structure (if needed)</li> <li>- Evacuation procedure</li> <li>- Information and decision management (Paton and Hannan, 2004)</li> </ul>	Similar to above

Table 7.3 Training Needs Analysis for Snow School

	Daily Tasks	Training Needs	Volcanic Event response tasks			Training Needs	Suggestions
			Pre-Event	Stage 1 – Initial Response	Stage 2 – Evacuation		
<b>Snow School</b>	<ul style="list-style-type: none"> <li>- Attend meeting assigning ski area locations</li> <li>- Give lessons to customers, out of Happy Valley, Hutt Flat, or Knoll Ridge, averaging an hour long</li> </ul>	<ul style="list-style-type: none"> <li>- Customer service</li> <li>- Most Snow School Instructors arrive pre-trained</li> </ul>	<ul style="list-style-type: none"> <li>- Provide information to customers and staff enquiring about the volcanic hazards at Ruapehu</li> <li>- Be positive role models for other staff members by treating the hazard as worthy of concern, and by treating each test of the warning system seriously</li> </ul>	<ul style="list-style-type: none"> <li>- <b>Immediately move to nearest safe areas with class</b>, helping them to remove equipment if necessary</li> <li>- Remain with customers in safe area, keep customers in area, and reassure them of their safety</li> </ul>	<ul style="list-style-type: none"> <li>- Attend to those injured and keep customers warm</li> <li>- <b>Wait for instructions (either verbally or over the radio from a senior staff member)</b>, do not move customers until authorized to do so by the head Ski Patroller, the ski area manager, or the Incident Controller, and then move customers to where you are requested to go</li> <li>- Provide information about customers and status when requested</li> </ul>	<ul style="list-style-type: none"> <li>- General information about the volcanic hazards at Ruapehu, eruption history, and frequency of events</li> <li>- Information about lahars, how they flow, lahar paths at the ski area, and safe areas</li> <li>- Information on the summit hazard zone at the ski area</li> <li>- Information about the warning system and warning times</li> <li>- Information on the correct response actions</li> <li>- Information on the evacuation plan, and the importance of remaining in safe area until authorized to move</li> <li>- Information on the development of realistic expectations of personal vulnerability</li> <li>- Information on different types of coping strategies and services that will be offered to staff, and the benefits of using them</li> </ul>	<ul style="list-style-type: none"> <li>- When explaining hazards and past eruptions, indicate what it means for contingent decision making and response, as well as using this information to develop stress resilience</li> <li>- Evacuation plan can be included in the general Health and Safety as the general evacuation procedure</li> <li>- Can reference similarity of lahar movement to avalanche to put it into context</li> <li>- Important to indicate how instructors are likely to get information as they do not carry radios</li> <li>- Coping strategies and services can be beneficial to learn for all emergency situations at the ski area</li> </ul>
<b>Snow School managers/supervisors</b>	Similar to above	Similar to above	Similar to above	<ul style="list-style-type: none"> <li>- If in safe area, assist Ski Instructors at grouping classes together, and moving inside building, if possible</li> <li>- <b>Begin taking names of customers</b></li> </ul>	<ul style="list-style-type: none"> <li>- When requested, <b>inform IC</b> as to how many classes and instructors were in possible danger areas at the time of the alarm</li> <li>- Take instructions from IC as to evacuation of the ski area</li> <li>- <b>Pass on list of names to Customer Services</b></li> <li>- At off-mountain location, help Customer Services to reunite groups</li> </ul>	<ul style="list-style-type: none"> <li>- CIMS structure (if needed)</li> </ul>	Similar to above

Table 7.4 Training Needs Analysis for Food and Beverage

	Daily Tasks	Training Needs	Volcanic Event response tasks			Training Needs	Suggestions
			Pre-Event	Stage 1 – Initial Response	Stage 2 – Evacuation		
<b>Food and Beverage</b>	<ul style="list-style-type: none"> <li>- Set up cafes for the day</li> <li>- Take orders, make and serve food to customers</li> <li>- Clean up</li> </ul>	<ul style="list-style-type: none"> <li>- Customer service skills</li> <li>- Food preparation</li> <li>- Alcohol responsibility training</li> <li>- Barista training</li> </ul>	<ul style="list-style-type: none"> <li>- Provide information to customers and staff enquiring about the volcanic hazards at Ruapehu</li> <li>- Be positive role models for other staff members by treating the hazard as worthy of concern, and by treating each test of the warning system seriously</li> </ul>	<ul style="list-style-type: none"> <li>- <b>Stop serving food</b></li> <li>- After manager has made an announcement, reassure customers</li> </ul>	<ul style="list-style-type: none"> <li>- Inform customers of what is happening</li> <li>- <b>Wait for instructions</b> (either verbally or over the radio from a senior staff member) do not move customers until authorized to do so by the head Ski Patroller, the ski area manager, or the Incident Controller, and then move customers to where you are requested to go</li> <li>- <b>Prepare cafes and buildings</b> to receive incoming staff and customers</li> <li>- Provide information about customers and status when requested</li> </ul>	<ul style="list-style-type: none"> <li>- General information about the volcanic hazards at Ruapehu, eruption history, and frequency of events</li> <li>- Information about lahars, how they flow, lahar paths at the ski area, and safe areas</li> <li>- Information on the summit hazard zone at the ski area</li> <li>- Information about the warning system and warning times</li> <li>- Information on the correct response actions</li> <li>- Information on the evacuation plan, and the importance of remaining in safe area until authorized to move</li> <li>- Information on the development of realistic expectations of personal vulnerability</li> <li>- Information on different types of coping strategies and services that will be offered to staff, and the benefits of using them</li> </ul>	<ul style="list-style-type: none"> <li>- When explaining hazards and past eruptions, indicate what it means for contingent decision making and response, as well as using this information to develop stress resilience</li> <li>- Evacuation plan can be included in the general Health and Safety as the general evacuation procedure</li> <li>- Can reference similarity of lahar movement to avalanche to put it into context</li> <li>- Indicate importance of making an announcement to customers and keeping them indoors</li> <li>- Coping strategies and services can be beneficial to learn for all emergency situations at the ski area</li> </ul>
<b>Food &amp; Beverage managers/supervisors</b>	Similar to above	Similar to above	Similar to above	<ul style="list-style-type: none"> <li>- Stop serving food</li> <li>- <b>Make an announcement that the lahar warning system has been activated</b> and that customers should stay inside the café, reassure them of their safety</li> <li>- Begin assigning staff members to take names of the customers in the cafe</li> </ul>	<ul style="list-style-type: none"> <li>- Report status to IC when requested</li> <li>- Assign staff members to <b>turn off roof water intakes</b></li> <li>- Prepare café to receive more customers, possible for overnight</li> <li>- If in area for a lengthy period, begin catering to customers, but <b>ration food</b></li> <li>- Assist IC in evacuation of mountain when requested</li> <li>- <b>Pass names on to Customer Services</b></li> </ul>	Same as above, but including: <ul style="list-style-type: none"> <li>- CIMS structure (if needed)</li> <li>- Location of water intakes</li> </ul>	Similar to above



Table 7.5 Training Needs Analysis for Rentals

			Volcanic Event response tasks			Training Needs	Suggestions
			Pre-Event	Stage 1 – Initial Response	Stage 2 – Evacuation		
	<b>Daily Tasks</b>	<b>Training Needs</b>					
<b>Rentals</b>	<ul style="list-style-type: none"> <li>- Get rental shop ready for the day</li> <li>- Rent gear to customers, size boots, set up skis</li> <li>- Intake equipment at end of day, put away</li> </ul>	<ul style="list-style-type: none"> <li>- Customer service</li> <li>- Sizing equipment</li> </ul>	<ul style="list-style-type: none"> <li>- Provide information to customers and staff enquiring about the volcanic hazards at Ruapehu</li> <li>- Be positive role models for other staff members by treating the hazard as worthy of concern, and by treating each test of the warning system seriously</li> </ul>	<ul style="list-style-type: none"> <li>- Stop renting equipment</li> <li>- Inform customers what is happening and that they are in a safe area</li> <li>- <b>Make sure customers remain in the area</b></li> </ul>	<ul style="list-style-type: none"> <li>- Inform customers of what is happening</li> <li>- <b>Wait for instructions</b> (either verbally or over the radio from a senior staff member), do not move customers until authorized to do so by the head Ski Patroller, the ski area manager, or the Incident Controller, and then move customers to where you are requested to go</li> <li>- Provide information about customers and status when requested</li> </ul>	<ul style="list-style-type: none"> <li>- General information about the volcanic hazards at Ruapehu, eruption history, and frequency of events</li> <li>- Information about lahars, how they flow, lahar paths at the ski area, and safe areas</li> <li>- Information on the summit hazard zone at the ski area</li> <li>- Information about the warning system and warning times</li> <li>- Information on the correct response actions</li> <li>- Information on the evacuation plan, and the importance of remaining in safe area until authorized to move</li> <li>- Information on the development of realistic expectations of personal vulnerability</li> <li>- Information on different types of coping strategies and services that will be offered to staff, and the benefits of using them</li> </ul>	<ul style="list-style-type: none"> <li>- When explaining hazards and past eruptions, indicate what it means for contingent decision making and response, as well as using this information to develop stress resilience</li> <li>- Evacuation plan can be included in the general Health and Safety as the general evacuation procedure</li> <li>- Can reference similarity of lahar movement to avalanche to put it into context</li> <li>- Indicate importance of making an announcement to customers and keeping them indoors</li> <li>- Coping strategies and services can be beneficial to learn for all emergency situations at the ski area</li> </ul>
<b>Rental managers/supervisors</b>	Similar to above	Similar to above	Similar to above	<ul style="list-style-type: none"> <li>- Stop renting equipment</li> <li>- <b>Make an announcement that the lahar warning system has been activated</b> and that customers should stay inside the rental building, reassure them of their safety</li> <li>- Assign staff to begin taking names of those in the rental building</li> </ul>	<ul style="list-style-type: none"> <li>- Report status to IC when requested</li> <li>- <b>Prepare building to take in customers</b></li> <li>- Assist IC in evacuation of mountain when requested</li> <li>- <b>Pass names on to Customer Services</b></li> </ul>	Same as above, but including: <ul style="list-style-type: none"> <li>- CIMS structure (if needed)</li> </ul>	Similar to above

Table 7.6 Training Needs Analysis for Customer Services

			Volcanic Event response tasks				
			Pre-Event	Stage 1 – Initial Response	Stage 2 – Evacuation		
	Daily Tasks	Training Needs				Training Needs	Suggestions
Customer Services	<ul style="list-style-type: none"> <li>- Issue snow report</li> <li>- Make sure schools and group tickets are prepared to go</li> <li>- Check email and phone messages</li> <li>- Get floats to various departments on ski area</li> <li>- Sell tickets, issue refunds, deal with customer complaints, customer enquiries</li> <li>- Print out tickets for schools and groups</li> </ul>	<ul style="list-style-type: none"> <li>- Customer service skills</li> </ul>	<ul style="list-style-type: none"> <li>- Provide information to customers and staff enquiring about the volcanic hazards at Ruapehu</li> <li>- Be positive role models for other staff members by treating the hazard as worthy of concern, and by treating each test of the warning system seriously</li> </ul>	<ul style="list-style-type: none"> <li>- <b>Stop selling tickets</b></li> <li>- Inform customers what is happening and that they are in a safe area</li> <li>- Make sure customers remain in the area</li> </ul>	<ul style="list-style-type: none"> <li>- <b>Help to coordinate communication</b> between ski area departments, Doc, and/or GNS</li> <li>- Avoid making uncertain and/or false statements. If unsure, tell people that and assure them you will find out</li> <li>- Set up one staff member to <b>prepare a register</b> of all customers reported missing</li> <li>- <b>Wait for instructions</b> (either verbally or over the radio from a senior staff member), do not move customers until authorized to do so by the head Ski Patroller, the ski area manager, or the Incident Controller, and then move customers to where you are requested to go</li> <li>- Provide information about customers and status when requested</li> </ul>	<ul style="list-style-type: none"> <li>- General information about the volcanic hazards at Ruapehu, eruption history, and frequency of events</li> <li>- Information about lahars, how they flow, lahar paths at the ski area, and safe areas</li> <li>- Information on the summit hazard zone at the ski area</li> <li>- Information about the warning system and warning times</li> <li>- Information on the correct response actions</li> <li>- Information on the evacuation plan, and the importance of remaining in safe area until authorized to move</li> <li>- Information on the development of realistic expectations of personal vulnerability</li> <li>- Information on different types of coping strategies and services that will be offered to staff, and the benefits of using them</li> </ul>	<ul style="list-style-type: none"> <li>- When explaining hazards and past eruptions, indicate what it means for contingent decision making and response, as well as using this information to develop stress resilience</li> <li>- Evacuation plan can be included in the general Health and Safety as the general evacuation procedure</li> <li>- Can reference similarity of lahar movement to avalanche to put it into context</li> <li>- General emergency communication procedures can be included in the general Health and Safety talk</li> <li>- Coping strategies and services can be beneficial to learn for all emergency situations at the ski area</li> </ul>
Customer Services manager/supervisors	Similar to above	Similar to above	Similar to above	<ul style="list-style-type: none"> <li>- Stop selling tickets</li> <li>- Assign a few staff member to proceed outside to help customers in the TOB area</li> </ul>	<ul style="list-style-type: none"> <li>- <b>Record a phone message</b> for incoming calls</li> <li>- Assist IC in communications</li> <li>- Prepare a few staff members to begin <b>registry of name</b> (both missing and present) by compiling sheets received from other staff members</li> <li>- Assist IC with evacuation of the mountain</li> <li>- <b>Avoid making false, uncertain statements.</b> If unsure, tell people that and assure them you will find out</li> </ul>	Same as above, but including: <ul style="list-style-type: none"> <li>- CIMS structure (if needed)</li> <li>- Emergency phone contacts</li> <li>- Plan in case of communication breakdown</li> <li>- Information and decision management (Paton and Hannan, 2004)</li> </ul>	Similar to above

Table 7.7 Training Needs Analysis for Road Services

	Daily Tasks	Training Needs	Volcanic Event Response Tasks			Training Needs	Suggestions
			Pre-Event	Stage 1 – Initial Response	Stage 2 – Evacuation		
<b>Road Services</b>	<ul style="list-style-type: none"> <li>- Clear roads and parking lots of snow</li> <li>- assess status of road, place restrictions if necessary</li> <li>- Set up parking lots, snow-chain trailer</li> <li>- Drive buses to pick up customers and staff</li> <li>- Help to offload buses</li> <li>- Keep an eye on traffic flow, monitor parking</li> <li>- Help staff and customers to leave the ski area, either by bus or car</li> </ul>	<ul style="list-style-type: none"> <li>- Customer service skills</li> <li>- Road safety</li> <li>- Equipment knowledge</li> </ul>	<ul style="list-style-type: none"> <li>- Provide information to customers and staff enquiring about the volcanic hazards at Ruapehu</li> <li>- Be positive role models for other staff members by treating the hazard as worthy of concern, and by treating each test of the warning system seriously</li> </ul>	<ul style="list-style-type: none"> <li>- <b>Stop all cars in the ‘loop’ at the TOB</b></li> <li>- Inform customers that they are in a safe area, ask them to remain there</li> <li>- <b>Set up roadblocks past the last parking lot so no one is able to leave the ski area</b> (due to the possibility of a lahar taking out the bridge)</li> </ul>	<ul style="list-style-type: none"> <li>- Inform customers of what is happening</li> <li>- <b>Wait for instructions</b> (either verbally or over the radio from a senior staff member), do not move customers until authorized to do so by the head Ski Patroller, the ski area manager, or the Incident Controller, and then move customers to where you are requested to go</li> <li>- <b>Do not let anyone proceed down the road</b> unless permission is given to do so</li> </ul>	<ul style="list-style-type: none"> <li>- General information about the volcanic hazards at Ruapehu, eruption history, and frequency of events</li> <li>- Information about lahars, how they flow, lahar paths at the ski area, and safe areas</li> <li>- Information on the summit hazard zone at the ski area</li> <li>- Information about the warning system and warning times</li> <li>- Information on the correct response actions, and the importance of keeping the Bruce Road empty</li> <li>- Information on the evacuation plan, and the importance of remaining in safe area until authorized to move</li> <li>- Information on the development of realistic expectations of personal vulnerability</li> <li>- Information on different types of coping strategies and services that will be offered to staff, and the benefits of using them</li> </ul>	<ul style="list-style-type: none"> <li>- When explaining hazards and past eruptions, indicate what it means for contingent decision making and response, as well as using this information to develop stress resilience</li> <li>- Evacuation plan can be included in the general Health and Safety as the general evacuation procedure</li> <li>- Can reference similarity of lahar movement to avalanche to put it into context</li> <li>- Coping strategies and services can be beneficial to learn for all emergency situations at the ski area</li> </ul>
<b>Road Services manager/supervisors</b>	Similar to above	Similar to above	Similar to above	<ul style="list-style-type: none"> <li>- Inform staff of warning system alarm</li> <li>- Assign staff members to set up roadblocks</li> <li>- <b>Stop all cars</b></li> </ul>	<ul style="list-style-type: none"> <li>- Report status to IC when requested</li> <li>- <b>Prepare all RAL vehicles</b> to assist in evacuation</li> <li>- <b>Make sure road is clear</b> for emergency vehicles</li> <li>- Prepare site for disaster victim identification</li> <li>- Assist IC in ski area evacuation</li> <li>- Get all customers and staff off ski area to off-mountain meeting place (possibly staff quarters)</li> </ul>	Same as above, but including: <ul style="list-style-type: none"> <li>- CIMS structure (if needed)</li> <li>- Location of disaster victim identification site</li> <li>- Information and decision management (Paton and Hannan, 2004)</li> </ul>	Similar to above

Table 7.8 Training Needs Analysis for Retail

	Daily Tasks	Training Needs	Volcanic Event response tasks			Training Needs	Suggestions
			Pre-Event	Stage 1 – Initial Response	Stage 2 – Evacuation		
<b>Retail</b>	<ul style="list-style-type: none"> <li>- Set up shop</li> <li>- Help and sell products to customers</li> <li>- Re-stock merchandise</li> <li>- Clean up store at end of the day</li> </ul>	<ul style="list-style-type: none"> <li>- Customer service skills</li> <li>- Merchandise knowledge</li> </ul>	<ul style="list-style-type: none"> <li>- Provide information to customers and staff enquiring about the volcanic hazards at Ruapehu</li> <li>- Be positive role models for other staff members by treating the hazard as worthy of concern, and by treating each test of the warning system seriously</li> </ul>	<ul style="list-style-type: none"> <li>- Stop selling merchandise</li> <li>- <b>Inform customers what is happening and that they are in a safe area</b></li> <li>- Make sure customers remain in the area</li> </ul>	<ul style="list-style-type: none"> <li>- Inform customers of what is happening</li> <li>- <b>Wait for instructions</b> (either verbally or over the radio from a senior staff member), do not move customers until authorized to do so by the head Ski Patroller, the ski area manager, or the Incident Controller, and then move customers to where you are requested to go</li> <li>- Provide information about customers and status when requested</li> </ul>	<ul style="list-style-type: none"> <li>- General information about the volcanic hazards at Ruapehu, eruption history, and frequency of events</li> <li>- Information about lahars, how they flow, lahar paths at the ski area, and safe areas</li> <li>- Information on the summit hazard zone at the ski area</li> <li>- Information about the warning system and warning times</li> <li>- Information on the correct response actions</li> <li>- Information on the evacuation plan, and the importance of remaining in safe area until authorized to move</li> <li>- Information on the development of realistic expectations of personal vulnerability</li> <li>- Information on different types of coping strategies and services that will be offered to staff, and the benefits of using them</li> </ul>	<ul style="list-style-type: none"> <li>- When explaining hazards and past eruptions, indicate what it means for contingent decision making and response, as well as using this information to develop stress resilience</li> <li>- Evacuation plan can be included in the general Health and Safety as the general evacuation procedure</li> <li>- Can reference similarity of lahar movement to avalanche to put it into context</li> <li>- Coping strategies and services can be beneficial to learn for all emergency situations at the ski area</li> </ul>
<b>Retail managers/supervisors</b>	Similar to above	Similar to above	Similar to above	<ul style="list-style-type: none"> <li>- Stop selling merchandise</li> <li>- <b>Make an announcement that the lahar warning system has been activated</b> and that customers should stay inside the retail area, reassure them of their safety</li> </ul>	<ul style="list-style-type: none"> <li>- Assist IC when requested</li> <li>- Help Food and Beverage staff with incoming customers</li> <li>- Assign staff to help Food and Beverage staff take names</li> <li>- Assist IC in evacuation of mountain</li> <li>- <b>Pass names on to Customer Services</b></li> <li>- Assist other staff at Off-mountain area once evacuated</li> </ul>	Same as above, but including: <ul style="list-style-type: none"> <li>- CIMS structure (if needed)</li> <li>- Evacuation plan</li> </ul>	Similar to above

Table 7.9 Training Needs Analysis for Groomers

	Daily Tasks	Training Needs	Volcanic Event response tasks			Training Needs	Suggestions
			Pre-Event	Stage 1 – Initial Response	Stage 2 – Evacuation		
Groomers	<ul style="list-style-type: none"> <li>- Groom runs</li> <li>- Fix equipment</li> </ul>	<ul style="list-style-type: none"> <li>- Equipment skills</li> <li>- Knowledge of ski area</li> </ul>	<ul style="list-style-type: none"> <li>- Be aware a lahar alarm may occur at any time, including during night shifts</li> </ul>	<ul style="list-style-type: none"> <li>- <b>Move to high ground</b></li> <li>- If not in an area where it is possible to drive to higher ground, get out and climb to high ground</li> </ul>	<ul style="list-style-type: none"> <li>- Wait for instructions over radio</li> </ul>	<ul style="list-style-type: none"> <li>- General information about the volcanic hazards at Ruapehu, eruption history, and frequency of events</li> <li>- Information about lahars, how they flow, lahar paths at the ski area, and safe areas</li> <li>- Information on the summit hazard zone at the ski area</li> <li>- Information about the warning system and warning times</li> <li>- Information on the correct response actions</li> <li>- Information on the evacuation plan, and the importance of remaining in safe area until authorized to move</li> <li>- Information on the development of realistic expectations of personal vulnerability</li> <li>- Information on different types of coping strategies and services that will be offered to staff, and the benefits of using them</li> </ul>	<ul style="list-style-type: none"> <li>- When explaining hazards and past eruptions, indicate what it means for contingent decision making and response, as well as using this information to develop stress resilience</li> <li>- Because groomers are less likely to be on the ski area during operating times, it is likely that the lahar hazard training can be shortened</li> <li>- Coping strategies and services can be beneficial to learn for all emergency situations at the ski area</li> </ul>
Groomer manager/supervisors	Similar to above	Similar to above	Similar to above	<ul style="list-style-type: none"> <li>- <b>Make an announcement over radio to staff</b> indicating the warning system has been activated</li> <li>- Communicate with staff to find positions on the mountain</li> </ul>	Day <ul style="list-style-type: none"> <li>- <b>Work with IC</b> on evacuation of the ski area</li> </ul> Night <ul style="list-style-type: none"> <li>- <b>Call emergency services</b></li> <li>- Try to locate all staff, and proceed off mountain if possible</li> </ul>	Same as above, but including: <ul style="list-style-type: none"> <li>- CIMS structure (if needed)</li> <li>- Evacuation procedure</li> </ul>	Similar to above

## 7.5 Recommendations

### Recommendation 1

*Calculate the number of people present on the ski areas in different circumstances*

It was determined during the interviews that staff are very unsure about how many people would be on the ski area during a busy Saturday, and where most of those customers would be located. This can create a problem during the response to a volcanic event, because those controlling the response will be unsure of how many customers will need to be evacuated. This can also influence the expected time it will take to evacuate the ski area.

This can be accomplished by recording customer numbers during different times of the ski season, such as the following:

- Weekend, fine weather, school holiday
- Weekend, bad weather, school holiday
- Weekday, fine weather, school holiday
- Weekday, bad weather, school holiday
- Weekend, fine weather
- Weekend, bad weather
- Weekday, fine weather
- Weekday, bad weather

These approximate customer numbers can then be listed in the ski area volcanic response plan, and will give those implementing the plan an idea of the numbers they will be dealing with. However, staff will need to be trained for a worst case scenario, and be trained in skills to handle large groups with varying degrees of stress, anxiety, etc.

### Recommendation 2

*Hold a yearly pre-season meeting with key RAL, GNS, and DoC staff and have emergency contact numbers (DoC, GNS) readily available*

It would be beneficial to all organizations involved in a potential response effort to send key members to meet with key RAL staff sometime during the off-season. This would help to familiarize those responding with each other, and also to set a plan for the upcoming winter season, in the way of:

- the plan for lahar hazard training, and warning system checks,
- potential dates for Stage 1 ski area simulation,
- potential dates for Stage 2 full evacuation simulation, and
- potential dates for the ski area volcanic hazard public surveys.

This will help RAL to work these dates into their busy winter season schedule, so as to make as little disruption to the company as possible. RAL can also bring up concerns or ideas in regard to the public education on volcanic hazards conducted at the ski area. Such a meeting was conducted before the 2005 winter ski season, and would be beneficial to continue into the future.

To try to minimize potential problems during a lahar response, emergency contact numbers from DoC, GNS, and any other potential organizations involved in the response (i.e. police, helicopter companies) must be researched beforehand and provided in the eruption response plan. Because numbers and contacts may change, this list should be updated yearly before the start of the winter season. Having these numbers available will mean that RAL is able to contact outside agencies immediately for assistance and information, making the response effort more efficient.

### Recommendation 3

#### *Run an evacuation simulation with permanent staff in March at Whakapapa*

While numerous simulations have been conducted on the ski area for Stage 1 of the response (initial), there has yet to be any practice on what will happen after Stage 1 is complete. Although previous recommendations have been made by Ward et al. (2003) to run a full-scale simulation during the ski season, this is likely impractical for RAL due to the amount of time that will be needed to run a full simulation and the amount of disruption that will be imposed on customers. Therefore, the best solution to this problem is to run a full-scale simulation in the off-season. Although seasonal employees will not be there to participate, permanent staff will be available. It is more imperative for permanent staff to participate in a full-scale simulation, as they will be the staff members that will be relied upon most during an evacuation. By running the evacuation in the off-season, this limits the amount of disruption to RAL and their customers. Although the situation will be slightly different as there will be no snow, the main benefits of running a simulation (practising on the field, receiving performance feedback, allowing management to discover problems with the plan, etc.) can all be accomplished. RAL will also begin to see which evacuation routes will likely work the best for them in certain situations.

### Recommendation 4

#### *Provide Snow School instructors with two-way radios*

During interviews with Snow School instructors, it was found they were quite worried about the response to a volcanic event because they were unsure of how they would get instructions or information about what was occurring if they were isolated with a group of students. Because Snow School Instructors are generally skiing on the ski area, they are at higher risk from volcanic hazards

than other staff such as Rental or Food and Beverage staff. They also have added responsibility because they will not only feel responsible for getting themselves to safety but also for looking after the students they will have with them. The author is unsure as to RAL's reasoning for not supplying Snow School instructors with two-way radios, as many other international ski areas supply their instructors with two-way radios. Providing these staff members with two-way radios would be beneficial for all safety situations on the mountain.

#### Recommendation 5

*Run a second test at Whakapapa during the ski season only if it is completely 'blind'*

This recommendation relates to the problems on the ski area this year with running a 'blind test'. The goal of a blind test is to have all staff at the ski area completely unaware of the impending alarm to get as honest a reaction as possible from the staff to gauge the effectiveness of the lahar hazard training. Therefore, unless the test can be completely 'blind', there is no benefit in having a second alarm during the ski season. It is possible that having the alarm sound multiple times during the ski season will desensitize staff and customers on the ski area, known as the 'cry wolf' effect (Atwood and Major, 1998). It was found by Breznitz (1984) that those afraid during a false alarm (which also can be generalized to include a blind test) are:

1. The least likely to pay attention to future warnings,
2. The most likely to downgrade the credibility of the warning system, and
3. The most resistant to taking protective action in the future.

Also, staff may become used to hearing two alarms in a ski season, leading them to respond slowly to a second alarm.

#### Recommendation 6

*Begin running yearly volcanic event simulations at Turoa and possibly a yearly full-scale evacuation in the off-season*

Because of the danger of volcanic hazards affecting the Turoa ski area, it is important for the ski area to begin running yearly Stage 1 simulations to familiarize their staff with the response actions they will need to take to complement the volcanic hazard training they receive during staff induction week. This will also allow management staff at Turoa to evaluate the effectiveness of their training session and to identify any gaps in response knowledge.

It would also be beneficial for Turoa to run a full-scale evacuation simulation in the off-season with permanent staff members. This would be beneficial for the response to other emergencies at the ski area, not only for volcanic events.



### Recommendation 7

#### *Hold a debrief with staff after each simulation*

In order for a simulation exercise to be effective, staff must be informed after the simulation of whether their response was appropriate and what could be improved. This could be most easily done in a department debrief, after closing on the simulation day, as managers and supervisors could go over what was seen and what could be changed. This will help to confirm the correct response actions to staff, giving them more confidence in a future event.

### Recommendation 8

#### *Place site-specific signs on the ski area in high danger locations*

In areas of high danger on both ski areas, it would be beneficial to have site-specific signs with brief, clear instructions on the correct response actions to take during activation of the warning system. At Whakapapa, areas that would benefit from these signs include the Far West area, the bottom of the Waterfall T-Bar, and the Staircase area under the Waterfall Express Chairlift. An example of the sign at the top of the Far West area would be “If lahar siren sounds, move immediately to ridgelines” and nothing more. It was determined that the development of a site-specific sign for the Far West area is currently being undertaken by RAL (Andy Hoyle, *personal communication*, 2005). At Turoa, it would be beneficial to have these signs at the top of the two highest T-Bars, the Jumbo and the High Noon. An example of the sign at the top of the High Noon T-Bar would be “If notified by staff a volcanic event is occurring, move immediately to ridgelines (high ground), and begin walking down ridge to the Giant Café” and nothing more. It is important to keep this message to the point as customers and staff will look to them for immediate instructions.

### Recommendation 9

#### *Increase education around times of higher risk or elevated volcanic activity*

It was suggested by a few staff members during the interviews that they believed it would be beneficial to increase the level of volcanic hazard education on the ski area during periods of increased risk. Times where this would become relevant include when the Crater Lake is at a high level or when the volcano is beginning to show signs of activity but not enough to warrant the closing of the ski area. This increase in public education can be as simple as ticket-sellers informing each customer that there is a higher risk from volcanic activity at the ski area and to respond immediately when the warning system sounds. The level of activity of the volcano can also be described by Snow School Instructors when teaching classes, and Lift Operators can also make small talk with customers in line informing them of the volcanic hazards at Ruapehu. However, this

must be done carefully so customers are not scared away. Therefore it is important to stress that Ruapehu is a unique area and that staff are trying to educate customers about the mountain.

#### Recommendation 10

##### *Laminate and paste specific lift response instructions to the wall in each lift drive station*

It was discovered that each lift-specific manual located in the lift drive stations contains the proper response procedure for each lift once the alarm has been activated. It would be beneficial if these instructions were photocopied, laminated, and stuck to the wall of the drive station for easy access during an emergency. Even if the lift operator knows the response actions, seeing them on the wall will give added confidence that they are taking the right actions.

#### Recommendation 11

##### *Help permanent staff on the ski area to become confident enough in their response to initiate it immediately*

During the response to a volcanic event, organizational authority will have to be suspended in favour of lower-level decision making for at least the initial phases of a lahar response (Galley et al., 2003). Therefore, effort must be made to increase the confidence of managers and supervisors who may be in positions of authority during that phase. The following are two examples of ways that this can begin to be achieved:

1. Continue encouraging returning staff to attend the Health and Safety course presented during staff induction week, and
2. Involve these staff in the full-scale evacuation simulation in the off-season.

The 2005 winter season staff induction was the first year that returning staff at Whakapapa ski area have been asked to attend the Health and Safety training (Andy Hoyle, *personal communication*, 2005). This is a positive step, as it was found during the interviews that some long serving staff at the ski area had never attended a lahar hazard training session before.

#### Recommendation 12

##### *Make volcanic hazards training sessions clearer and more concise*

The volcanic hazard training sessions held during RAL staff induction week have improved considerably in the last few years, thanks to a renewed commitment and enthusiasm put forth by key RAL management. However, this year some training sessions were found to be long, as the material could be covered just as efficiently in a shorter time period. The following include recommendations of the main points to be covered during staff induction training.

*A. Continue training each department separately and consider bringing in a DoC staff member to assist with running the training*

Most staff interviewed commented on the improvement in lahar hazard training at the ski area over the past year. Part of this improvement is likely due to separating the departments, as the session leader is able to focus on teaching each department the role they will play. It also may be beneficial to bring in a DoC staff member from Whakapapa Village involved in the warning system at the ski area to assist with running the training. This will show staff that RAL takes the risk seriously and has relationships with outside agencies for handling the hazard. The DoC staff member may also be able to make valuable contributions like explaining the volcanic hazard and warning system.

*B. Focus on explaining past eruptions and impacts on the ski area (10 minutes)*

During the interviews, it was found that each staff member had a very different idea of past eruptions at the Ruapehu and the effects on the ski area. This means that staff members may have very different expectations of a future eruption at the ski area. This can be easily covered by explaining the past three major eruptions (1969, 1975, and 1995/96) and their impacts on the ski area. It is important to mention that none of the historical eruptions at Ruapehu have contained flowing lava. It may be beneficial to show news footage of the 1995/96 eruption and impact on the ski area. This will also help to explain to staff how a lahar acts and looks. A member of RAL who experienced the 1995/96 eruptions could also be brought in to briefly share their experience.

*C. Explain the warning system (<5 minutes)*

It is important for the warning system at Whakapapa and Turoa ski areas to be explained to staff in the simplest terms possible. It is not important for staff to know the location of seismometers, but more important for them to understand how the alarm will sound and the importance of responding quickly. The warning times associated with a lahar entering the ski areas can also be explained here.

*D. Explain their role, perhaps using public education materials (5 minutes)*

An important part of training is explaining to staff member their role in the response to a volcanic eruption. RAL has already begun to divide into departments for the training, which is extremely beneficial for being able to explain in detail the role their department will play. It may be useful to pull out the public education posters during this section of the training, so that staff are able to see where lahars will affect the ski area and can determine what their response should be dependent on which part of the ski area they are in.

*E. Explain how a ski area evacuation would occur, taking an all-disaster approach (<5 minutes)*

This includes explaining what the overall ski area response will be, so that staff can get an idea of what their role will be in relation to other departments. It is also useful to explain to staff what the overall procedure will be after the initial event has passed, such as if they should wait for instructions before moving off the ski area or if they should immediately head for the closest building.

*F. Include stress resilience training (5 minutes)*

It is important during the training session for staff to discuss different situations they may come across during the response to a volcanic event and emotions they may feel. It should be stressed to staff that these emotions are normal, and various ways to cope with these feelings should be explained. This stress resilience training can be used proactively to manage potential symptoms relating to stress and trauma (Paton and Flin, 1999; Paton and Jackson, 2002). Any support services that will be offered to staff after a volcanic event should also be explained (i.e. debriefing and counselling) and the benefits of using these services should be covered.

**Recommendation 13**

*Write a ski area action plan, including designating an off-mountain meeting point and plans for communication*

Firstly, the ski area will need to decide if CIMS is the most efficient structure for them to use in the response to a volcanic event (see Section 7.3.4 for a detailed discussion). If the ski area decides to follow CIMS guidelines when responding to an emergency situation, they will first need to write an Initial Action Plan (IAP). This plan can be constructed based on the training needs analysis in Section 7.4, as RAL can get an idea of tasks that will need to be done and problems that may be encountered during a response. Potential evacuation routes from high risk areas should be listed in the plan. It will also be important to designate an off-mountain meeting point, as customers and staff will need to be evacuated to one location so managers are able to account for everyone. An example of an appropriate area may be the RAL staff quarters/Skotel area, which is also out of any potential secondary lahar paths in Whakapapa Village.

The plan for communication must also be thought of beforehand. This also must include a backup plan in case the main method of communication fails (i.e. two-way radios). Considering how the media will be handled is another important matter, as a volcanic event affecting the ski area has the potential for international attention. Clark (1996) describes that:

“past disasters show that companies have failed to consider how the media was to be handled, only to find that their devastating experience is being broadcast over the radio or television without any plan for how to deal with the flood of incoming calls from family members and concerned individuals.” (p. 43)

Consistent with previous research, Galley et al. (2003) also suggests communication will be an essential part of the response plan. However, information management, which is separate from communication, is another key training issue (Paton and Hannan, 2004). This will help staff to understand what is being communicated and whether it is meaningful to the recipients (Paton and Hannan, 2004).

The plan must also be supported by all levels of management at the ski area.

#### Recommendation 14

*Work with DoC to possibly arrange adding more speaker sites on Whakapapa, and adding speakers to the top area of Turoa*

It may be beneficial on Whakapapa to increase the speaker coverage, as during the 2005 tests it was found that in some areas the volume of the warning system was less than ideal. DoC should also be responsible for testing the warning system before the beginning of the ski season (as opposed to the first simulation) to avoid placing skiers and staff at unnecessary risk at the beginning of the season.

It would also be useful for the warning system to be expanded to Turoa, by the addition of speakers near the top two T-Bars at greatest risk. Management at Turoa seem very open to this idea, so it would just be a matter of negotiation between DoC and RAL as to who should pay for these speakers and where they should be placed for greatest efficiency.

#### Recommendation 15

*Train building fire wardens to also be an ‘eruption’ warden*

It was suggested by a few staff members during the interviews that each building should have an ‘eruption’ warden, similar to a fire warden. This is an excellent idea which would likely minimize confusion, as the ‘eruption’ warden could take a leadership role in each building amongst staff during a volcanic event response. The simplest way to accomplish this is to use the building fire warden also as an ‘eruption’ warden, and train them in the proper eruption response actions when they receive their fire training.



## Chapter Eight

# Conclusion

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### 8. CONCLUSION

The situation RAL faces at Whakapapa and Turoa ski areas is unique compared to most other ski area companies worldwide. The amount of work and responsibility RAL has put into preparing their staff for a volcanic event is to be admired, considering the low frequency of a volcanic event affecting the ski area compared to other natural hazards. It is important for RAL to be aware of factors that can constrain organizational commitment (Section 7.1) and to work at overcoming these factors in order to be prepared for a volcanic event that may have extremely serious consequences for the ski area.

Four main objectives were put to test during this research, and the conclusions are as follows (Section 7.3):

- Staff were found to be knowledgeable about the volcanic hazards at the ski areas but had differing perceptions of the risk associated with those hazards,
- Staff were found to be knowledgeable and confident in the Stage 1 (initial) response to a volcanic event, however were unsure of what a Stage 2 (evacuation) response would involve,
- RAL has made significant improvement in recent years to their volcanic hazard training (including staff training during induction week, simulations, and blind tests), however minor changes can be made to improve the effectiveness, and

- RAL needs to develop a specific ‘plan’ for how they will deal with a volcanic event, as applying broad emergency plans will likely be unproductive during the response to a volcanic event.

The following recommendations were then made:

- 1. Calculate number of people present on the ski areas in different circumstances*
- 2. Hold a yearly pre-season meeting with key RAL, GNS, and DoC staff, and have emergency contact numbers (DoC, GNS) readily available*
- 3. Run an evacuation simulation with permanent staff in March at Whakapapa*
- 4. Provide Snow School instructors with two-way radios*
- 5. Run a second test at Whakapapa during the ski season only if it is completely ‘blind’*
- 6. Begin running yearly volcanic event simulations at Turoa and possibly a yearly full-scale evacuation in the off-season*
- 7. Hold a debrief with staff after each simulation*
- 8. Place site-specific signs on the ski area in high danger locations*
- 9. Increase public education around times of higher risk*
- 10. Laminate and paste specific lift response instructions to the wall in each lift drive station*
- 11. Help permanent staff on the ski area to become confident enough in their response to be able to initiate it immediately*
- 12. Make volcanic hazards training session clearer and more concise:*
  - a. Continue training each department separately and consider bringing in a DoC staff member to assist with running the training.*
  - b. Focus on explaining past eruption and impacts on the ski area*
  - c. Explain the warning system*
  - d. Explain their role, perhaps using public education materials*
  - e. Explain how a ski area evacuation would occur, taking an all-disaster approach*
  - f. Include stress resilience training*
- 13. Write an overall CIMS based ski area action plan, including designating an off-mountain meeting point and plans for communication*
- 14. Work with DoC to possibly arrange adding more speaker sites on Whakapapa, and adding speakers to the top area of Turoa*
- 15. Train the building fire wardens to also be ‘eruption’ wardens*

## Acknowledgements



*RAL staff at the Crater Lake, 2005 season*

There are many people to thank in regards to the completion of this thesis. First and foremost thanks goes to the staff at RAL, who treated me like one of the crew during my time at Whakapapa and Turoa – especially Vicky, Emily, Anneke, Vivian, and Jake. A huge thanks also to the management staff at RAL, especially Andy Hoyle and Chris Emmett for letting me observe their staff training and helping to set up the interviews and surveys. Thanks also to Vicky Norman and Jane McGechan, who were awesome at helping me with anything I needed. And thanks to Vicky Leahy, Scott Barnard, and Grant Kaye for providing some of the pictures used in this thesis.

I would also like to thank the DoC staff at Tongariro National Park, particularly Harry Keys and Nicki Hughes (Shorty). Biggest thanks goes to Pete Blaxter, for being incredible at helping me out with my project but more importantly for being a great friend!

To my fellow students: my time in NZ wouldn't have been the same without meeting all of you and I wish you each the best in your future endeavours. Big thanks to Jo and Olivia (the best officemates!), Carol, Francie, Tenille, Scott, Grant, Kirsten, Andrew, Kelly, Sarah, and Sophie. Also to my kiwi friends, thanks for everything: Prue, Paul, Anne, Stu, Maria, Cam, and Ruth.

I would also like to thank my supervisory team of Graham Leonard, David Johnston, Douglas Paton, and Jim Cole for all their support. Graham: for helping to set me up at Ruapehu and most importantly for remembering what it was like to be a student. David: for all your funding and research help, but more importantly for making me laugh. Douglas: for listening to all my questions, leading me in the right direction, and being great at getting stuff back to me quickly. Jim: for helping me realize my dream to study in New Zealand.

I would also like to thank my family and friends back in Canada for all their support during the two years we have been in New Zealand, particularly Cara, Craig, Roxanne, Hendrika, Shaun, Andrew, Jodie, Jimmy, Kiana, Dylan, Anita, Mike, Haley, Betty, Wally, and my grandparents. I am also indebted to my parents, who have been wonderful at supporting us even though we are half a world away. I could never have done this study without them, and je vous aime tous les deux profondément. To my husband Blake – I don't know what I would have done without your patience and support during this time. Tu es mon meilleur ami et je t'aimerai toute ma vie. Je suis excite por notre avenir.





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## **APPENDIX 1: DEPARTMENT SPECIFIC TRAINING OBSERVATIONS DURING TUROA AND WHAKAPAPA STAFF INDUCTION WEEKS**

### *1. Lift Operators*

#### Turoa

Lift Operations staff for this session consisted of new and returning staff. Staff were explained the warning system, and that some staff on both areas have pagers which are linked to the EDS to inform all parties. The 1995/96 eruptions were also explained, with staff told that although it was quite a small eruption, it was still scary, as the mountain was spewing ash and sounded like a jet engine. The Tangiwai rail disaster was also explained. Lift Operations staff were also informed that the main hazard at Turoa is ballistic bombs in the summit hazard zone.

The correct response actions were then explained to the Lift Operations staff. They need to inform customers if they are alerted of an eruption and direct them to safe areas, which are usually cafes. Chairlifts must also be run at maximum speed to unload customers, and then everyone must move to higher ground. All surface lifts must be stopped. Lift Operators are then required to wait for instruction of either Ski Patrol or their supervisors on the evacuation of the mountain.

Lift Operation staff were unsure if there would be any warning signs before an eruption, and were told that the 1995 eruption occurred with no warning and there were skiers on the mountain. In panic, people quickly tried to get off the ski area and lift operators left their stations, which is what they are now working to avoid

The lahar hazard video was not played, as the audio was not working.

#### Whakapapa

Lift Operations staff for this session consisted of new and returning staff, as well as supervisors and managers. Most staff seemed knowledgeable that Ruapehu was an active volcano, and were told the volcano was one of the most active in the world. Lahars were indicated as the key hazard, and consisted of a dense flow of mud and ash which flows quickly (60 to 90 km/hr) down the valleys. Staff were then split into groups and asked to come up with the main volcanic hazards at the ski area. The warning system was then explained, including how the announcement sounds. Lift operators were identified as a key part of the response plan. The session leader then indicated that it was also important to think of the next step after the alarm sounds, because people will begin to



panic and want to leave. Staff were told it is important to stay calm, as customers will look to them for a leadership role. Public education posters were then handed out to staff, and they were asked to think of what they would do if they heard the alarm sound. Responses included speeding up lifts to get customers off, moving people to safe areas, stopping T-Bars, and keeping people in safe areas, which were all indicated as correct responses with a trend towards keeping the public safe and minimizing damage. It was also made clear to Lift Operators that lifts may be damaged, hence the importance of removing people from the lifts quickly.

Staff also enquired about how quickly a lahar would enter the ski area, and were told it is likely take three minutes from the crater to the first T-Bar. Staff also asked if they would likely feel an earthquake before an eruption, but were told they may not feel any seismicity or warning signs, and that it was important to treat the sounding of the warning system as a real test each time. If in doubt of what to do, staff were told to talk to their supervisors. Staff were also interested in discussing if anyone had died during an eruption at Ruapehu before. It was also discussed that there is a traditional feeling that Turoa is safe, however there were other hazards Turoa may have a problem with, such as ballistic bombs if close enough to the crater. Lift operators were told that they have lahar specific instructions in their lift manuals, and that RAL aims to have a general practice run of the warning system during the season. Lift operators were told they needed to concentrate on the initial action plan, and not to worry about the later evacuation plan.

The video was then shown, but only worked for the first few minutes.

## *2. Customer Services*

### Turoa

Customer service staff for this session consisted of both new and returning staff. They were told that the eruption in 1995 was a ‘blue-sky’ eruption, where no one knew the volcano was going to erupt. It was also explained that there were various warning levels of volcanic activity, and that the managers would make the call on when to close the ski area. Ballistic bombs and ash were described as the key hazards. Customer service staff were concerned about who would be responsible for informing people if the pager systems were to go off, and were told they would have a key role in telling other departments the appropriate response. The main response action would be informing customers and directing them to safe areas, such as the car park and cafes. Ski Patrol would then be responsible for clearing the mountain. The session leader also indicated that Turoa likely would be fine during an eruption event. Staff were then shown the video. Customer service staff were concerned about whether there would be warning signs from the mountain, and

were told that they would possibly hear the eruption but may not be able to see it. The eruption event itself was described as ‘awesome’ and ‘not that scary’.

### *3. Food and Beverage*

#### Turoa

Food and Beverage staff for this session consisted of both new and returning staff. The warning system at the ski area was first described to food and beverage staff, with pagers alerting key staff to know which activity level is present on the mountain and whether the EDS has been activated. Staff were also told that if there was an eruption, everyone would be well off. The public education brochure was then handed out, and the difference between the two ski areas was described. Food and beverage staff were told they were to tell people to stay in the cafes as the cafes are a safe area. Ski Patrol and supervisors would then tell staff when to move and where to. Food and beverage staff were also told that it applies more to Whakapapa, however higher ground is still the place to be. The video was then shown, however had problems at about five minutes and was stopped.

#### Whakapapa

Food and Beverage staff for this session consisted of both new and returning staff. Food and Beverage staff were immediately split into groups and asked to discuss why the volcano was a problem for the ski area. Most staff thought that lahars would be the biggest problem, which were described to them by the session leader as forming when an eruption shoots the Crater Lake water into the air which lands and melts the snow, rushing down valleys and entraining rocks. Staff also mentioned ash and poisonous gases as being a problem. The session leader explained the likely warning signs from the volcano, such as increased seismicity and increase in lake water temperature, and that the volcano erupts every 10 to 15 years. It was also stressed to staff that they were safe in buildings and that the main job was to keep customers calm.

The warning system at Whakapapa was then described to staff, and it was noted that there would be a test early in the season. Staff were told that the top lifts would only have three minutes warning time. Staff were concerned if anyone had ever been killed during an eruption and were told there hadn't been any deaths on the ski area just damage to structures. The public education posters were then handed out, so staff could familiarize themselves with the lahar paths, summit hazard zone, and safe areas. Food and Beverage staff were also told their personal safety was the most important thing, and that they should try to keep people in cafes, keep them calm, and give them information. Staff were concerned that Happy Valley was a safe area even though it was in a valley, however it

was explained to them that there is a deeper valley up above that will channel the lahar flow so there is no danger of it entering Happy Valley. Staff were also told there was an evacuation plan for getting everyone off the mountain, and that some possible complications to the evacuation plan would be food, water, and communication problems, and also the added complication of the weather possibly being bad. It was also stressed it is important for staff not to cross lahar paths as the ground may not be stable. The staff were also told that public education posters would be everywhere on the ski area to maximize customer awareness, and that staff would be needed to help inform customers of the risk.

The video for this session did not work.

#### *4. Road Crew*

##### Turoa

Road Crew staff for this session consisted of new staff only. The volcanic warning system was first explained to road crew staff. They were told the main volcanic hazard at Turoa was ballistic bombs, as Turoa does not get as many lahars as Whakapapa. Turoa was summed up as being not that dangerous. Staff were concerned a bigger hazard may be gases or debris, but were told that was dependent on the way the wind was blowing. However, staff were told that eruptions do happen, such as 1995/96, when Turoa did not have a warning system. The event occurred without warning, and customers were unsure of what to do so everyone ran off, including staff. However, road crew staff were told that their main response action for a volcanic event is to stay in position and take responsibility for the road and traffic signs. It was also explained that the ski area is likely to be closed if it was too dangerous. Staff were also warned if it was a crappy day it may not be obvious the volcano was erupting. Road crew staff were unsure of what 'high ground' meant, and were advised that it means to move out of valleys, similar to the response to an avalanche.

The video was then played, and staff were concerned that there was no sounding siren at Turoa like there was at Whakapapa. However, the session leader indicated there was one around the base area at Turoa, which would be expanded for the rest of the ski area, but that the danger at Turoa isn't from lahars. Road crew staff also indicated they wouldn't have to worry because they wouldn't be on the mountain during an eruption, however it was stressed to them it is important to know because they may be skiing or up on the mountain at the time of an eruption.

## 5. *Snow School*

### Whakapapa

Snow School staff for this session consisted of returning staff only, as new staff were due to arrive at the ski area in two weeks time and would attend a Health and Safety session then. They were first asked what the main hazards were from a volcanic eruption. Lahar was the first answer, which they believed could either be created by the side of the Crater Lake giving way or by an eruption. Other hazards mentioned included pyroclastic flows, earthquakes, and ash. The session leader explained that although pyroclastic flows aren't common at Ruapehu, they still can't be discounted.

The initial response plan was then discussed, which the session leader described as something he also did not want to deal with but would have to, as the ski area is responsible. Snow School staff thought the biggest problem on the ski area would be panic. The session leader agreed, indicating that is why it is important for anyone in an RAL uniform to take a leadership role. Staff were then encouraged to think of what they would do if they heard the warning system. Common answers included dropping equipment, getting people to safe ground, making sure they are safe, getting names and numbers, reassuring people, and making them remain in safe areas. It was indicated to staff that no matter where they were on the ski area, it was important to move to high ground as the lahar could go anywhere. Past lahar damage at the ski area was also discussed.

It was also mentioned that in past tests Food and Beverage staff haven't realized they need to take an active role in keeping people inside. It is also important to initiate the response plan as soon as the warning system is heard, and that the best plan was a solid response and high public awareness. The warning system was then explained to staff, and different environmental conditions that may hinder the warning system were discussed. The higher risk at the Far West T-Bar was also brought up, as well as the summit hazard zone. Snow School staff were also told their primary response actions were to move their group to high ground, leaving equipment behind, and spread word about what is happening. Phase 2, the evacuation phase, was also discussed, as every staff member will be needed to help manage groups of people. The importance of treating every alarm as a real one was also stressed, as the ski area managers will not know immediately if it is a real alarm. The lahar safety video was then shown.

## 6. Groomers

### Whakapapa

Groomer training consisted of both new and returning staff, as well as supervisors, who were first told they work on an active volcano which erupts regularly. Staff were told that at Whakapapa, the main threat was from lahars which could occur 10 to 20 years, whereas at Turoa the main threat was from ballistic bombs. Groomer staff thought that the Crater Lake wall collapse could affect the ski area, however were told that is not a threat to the Whakapapa ski area. The session leader described a lahar as mud, rock, and water, which was kind of like lava, and could travel up to 90 km/hr. The Eruption Detection System (EDS) was then described and it was noted it only exists at Whakapapa. Groomers were concerned they may not be able to hear the siren from inside their machine, so it was then decided to supply the manager with a pager to alert him when the warning system was sounded and then he could radio the alert to his crew.

The 1995 lahar was also discussed and the risk it would have had to people if it would have occurred during the day. Staff were also told to look at volcanic hazards posters around the ski area, as there was lots of good information on them. The summit hazard zone was then described, and staff watched the lahar hazard video. Because the video mainly talked about the response of people on skiers, groomer staff were then broken up into groups to talk about what their response would be. Staff were told the correct action would be to drive to higher ground, or drive out of dangerous areas such as the Gutt or Turnpike where there was no way to get to higher ground. It was agreed upon that groomer staff would not immediately be in a position to help customers, however once they were safe it was important for them to inform customers and point people to where they need to go. The session leader also discussed that in tests, people have just ignored the warning system or have fallen over in a panic, which puts pressure on Ski Patrol to remove everyone from lahar paths. The time frame between when the alarm was sounded and when it could be determined if it was a real alarm was estimated at 10 to 15 minutes. It was also stressed to staff that it was not up to RAL to determine whether the alarm was false. Staff would then need to follow instructions from their supervisor on evacuating people. Groomer staff then wanted to know if there was a specific channel for informing people of what was happening, and were told that the Ski Patrol would be using their channel.

## **APPENDIX 2: INFORMATION SHEET, CONSENT SHEET, AND 2005 STAFF SURVEY**

### **Information Sheet – Management staff interviews**

To Whom It May Concern:

Thank you for taking the time to participate in this interview. I am a Masters student at the University of Canterbury in the Department of Geological Sciences, specializing in Hazards Management. I am working with the Institute of Geological and Nuclear Sciences on volcanic hazards at Ruapehu. My research focuses on staff training at Whakapapa and Turoa ski fields for a volcanic event. These interviews will be used to gauge the current level of thinking of management staff at RAL on volcanic hazards on Ruapehu, specifically lahar hazards.

Participation is voluntary. In no way will the results of the interview have any outcome on your position at Ruapehu Alpine Lifts. All interviews will be kept confidential, and will be securely stored. Information from these interviews will be used to develop recommendations on how to improve staff training at Whakapapa and Turoa ski fields.

Thanks

Amy Christianson

**Consent Sheet**

I, \_\_\_\_\_, give Amy Christianson at the University of Canterbury permission to record this interview, and to use information from my responses in this interview in her MSc. Thesis and a GNS report.

\_\_\_\_\_  
Signature of interviewee

\_\_\_\_\_  
Date

## **Ruapehu Alpine Lifts – Staff Survey - Lahar Training**

### GENERAL

Which ski field do you work at?:    \_\_\_ Whakapapa        \_\_\_ Turoa

What area(s) will you predominantly work in this season?: *(Tick all that apply)*

- \_\_\_ Permanent Staff/Management
- \_\_\_ Ski Patrol
- \_\_\_ Lift Operator
- \_\_\_ Snow School
- \_\_\_ Customer Services
- \_\_\_ Food and Beverage
- \_\_\_ Rental/Workshop/Retail
- \_\_\_ Groomers
- \_\_\_ Other: \_\_\_\_\_

How long have you worked on this ski field?: *(Tick one)*

- \_\_\_ 1<sup>st</sup> Year    \_\_\_ 2<sup>nd</sup> Year    \_\_\_ 3<sup>rd</sup> Year    \_\_\_ More

### SPECIFIC

*The following questions relate to lahar staff training:*

1. Please provide as detailed a description as possible for the following questions:

- a) What is a lahar? \_\_\_\_\_
- b) How does a lahar act? \_\_\_\_\_
- c) If a lahar occurs, how much warning time would there be before it affects the ski field? \_\_\_\_\_
- d) What are the potential hazards from a lahar? \_\_\_\_\_  
\_\_\_\_\_

2. Do you think lahar training is important? **Y / N**

Why/ Why not? \_\_\_\_\_  
\_\_\_\_\_



3. When do you think the next volcanic event is likely to affect the ski field? (*circle one*)

Within the next year                      Within your lifetime                      Don't know  
Within the next 10 years                      Not within your lifetime

4. What are the components that make up the lahar warning system at your ski field?

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5. Do you feel RAL is prepared to handle an emergency situation? **Y / N**

Why/ Why not? \_\_\_\_\_

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6. Were your role requirements during a lahar warning (i.e. actions you will be expected to take) explained clearly? **Y / N**

a) What are they?

---

b) Does it involve working with others? **Y / N**

c) If so, do you feel your training for working with others was adequate? **Y / N**

Why/ Why not? \_\_\_\_\_

---

7. What sorts of situations do you think could be most stressful when the lahar warning system activates?

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8. a) What are the different possible reactions from customers to a lahar warning?

---

b) What kinds of customer needs do you think you might have to deal with?

---

c) Do you think you have received adequate training to deal with these issues? **Y/ N**

Why/ Why not? \_\_\_\_\_

---

9. What are the potential consequences to skiers in the path of a lahar when it enters the ski field?

---

10. Have you seen any public education on volcanic hazards at your ski field? **Y / N**

What does it say? \_\_\_\_\_

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## APPENDIX 3: 2005 WINTER SEASON STAFF SURVEY RESULTS

### Results

**Table 1: Which ski field do you work at?**

	Responses	
	Count (n=89)	Percent (%)
Whakapapa	70	78.7
Turoa	19	21.3

**Table 2: What area(s) will you predominantly work in this season?**

	Responses	
	Count (n=89)	Percent (%)
Permanent Staff/Management	4	4.5
Ski Patrol/ Trail Safety	1	1.1
Lift Operator	9	10.1
Snow School	10	11.2
Food and Beverage	21	23.6
Rental/Workshop/Retail	37	41.6
Road Services	7	7.9

**Table 3: How long have you worked on this ski field?**

	Responses	
	Count (n=89)	Percent (%)
1st Year	59	66.3
2nd Year	17	19.1
3rd Year	4	4.5
More	8	9.0
Missing	1	1.1

**Table 4: What is a lahar?**

	Responses	
	Count (n=89)	Percent (%)
Volcanic mudflow	43	48.9
Ice/slush/mudflow from volcanoes	1	1.1
A flow of geological material caused by volcanic activity	1	1.1
Flash flood of hot mud and debris	6	6.8
Mud/ash/water flow	13	14.8
A landslide caused by a volcanic eruption, includes debris	2	2.3
Debris and water from crater when volcano erupts	1	1.1
Mudslide	12	13.6
A hot liquid that comes out of the mountain	1	1.1
Lava	7	8.0
From an eruption	10	11.4
Muddy water flow from Crater Lake	5	5.7
Hot	13	14.8
A volcanic flow of ash	1	1.1

**Table 5: How does a lahar act?**

	Responses	
	Count (n=89)	Percent (%)
Like a flash flood	9	10.1
Flows like a river	12	13.5
Like an avalanche	1	1.1
runs downhill taking out everything in it's path	1	1.1
Anyway it wants	2	2.2
Runs downhill, usually in valleys	20	22.5
Fast moving	15	16.9
Flows down the hill but not very fast	1	1.1
Mudflow	3	3.4
Violently	1	1.1
Slides down mountain	3	3.4
flows down the mountain	10	11.2
Like thick porridge flowing downhill	1	1.1
Like a tsunami coming down a mountain	1	1.1
runs down particular paths	3	3.4
Didn't understand	4	4.5
No Response	2	2.2

**Table 6: If a lahar occurs, how much warning time would there be before it affects the ski field?**

	Responses	
	Count (n=89)	Percent (%)
Not much	20	22.5
2-5 minutes	14	15.7
5 minutes	16	18.0
5 to 10 minutes	6	6.7
10 minutes	10	11.2
10 minutes to an hour	9	10.1
Over an hour	1	1.1
Don't know	4	4.5
Didn't understand	4	4.5
No Response	5	5.6

**Table 7: What are the potential hazards from a lahar?**

	Responses	
	Count (n=89)	Percent (%)
Death	46	55.4
Injury	18	21.7
Burns	3	3.6
Removal of snow	1	1.2
Damage to lifts	15	18.1
Damage to ski area	11	13.3
Damage to buildings	16	19.3
Burial	5	6.0
Being trapped	1	1.2
Flash floods in rivers	7	8.4
Being swept away by one	16	19.3
Closure of ski field	6	7.2
Air pollution	1	1.2
Avalanche	3	3.6
Water supply contamination	1	1.2
Ecological repercussions	2	2.4
Anything in its path is destroyed	6	7.2
Gas	3	3.6
Rocks	8	9.6
Mudflow	5	6.0
People's reaction	2	2.4

**Table 8: Do you think lahar training is important?**

	Responses	
	Count (n=89)	Percent (%)
Yes	86	96.6
No	2	2.2
No response	1	1.1

**Table 9: Why do you think lahar training is important?**

	Responses	
	Count (n=89)	Percent (%)
To prevent accidents and fatalities (for safety)	38	43.7
To increase awareness	33	37.9
To learn correct response actions	37	42.5
Because there are going to be lots of panicked people.	2	2.3
Because the volcano could erupt at any time	15	17.2
We are responsible for the wellbeing and safety of our customers	1	1.1
It's not, because I don't live near volcanoes	1	1.1
It's not, because I'm working in a safe zone	2	2.3

**Table 10: When do you think the next volcanic event is likely to affect the ski field?**

	Responses	
	Count (n=89)	Percent (%)
Within the next year	25	28.1
Within the next 10 years	34	38.2
Within your lifetime	15	16.9
Don't know	14	15.7
No response	1	1.1



**Table 11: What are the components that make up the warning system at your ski area?**

	Responses - Whakapapa	
	Count (n=80)	Percent (%)
Monitoring	16	24.2
Siren and speakers	53	80.3
Radio	1	1.5
Announcement	23	34.8
Staff	13	19.7
Signs	1	1.5
EDS	14	21.2
DoC	2	3.0
Cameras	1	1.5

	Responses - Turoa	
	Count (n=19)	Percent (%)
Monitoring	11	58.0
Siren and speakers	6	31.6
Radio	0	0
Announcement	2	10.5
Staff	2	10.5
Signs	0	0
EDS	5	26.3
DoC	0	0
Cameras	0	0

**Table 12: Do you feel RAL is prepared to handle an emergency situation?**

	Responses	
	Count (n=89)	Percent (%)
Yes	66	74.2
No	13	14.6
Don't Know	1	1.1
Sort of	6	6.7
No response	3	3.4

**Table 13: Do you feel RAL is prepared to handle a volcanic emergency?**

	Responses	
	Count (n=89)	Percent (%)
Yes, because of previous experience	13	16.9
Yes, because of help from DoC and other groups	4	5.2
Yes, because key staff are well trained	8	10.4
Yes, because of the health and safety course	19	24.7
Yes, because they are aware of the hazard	9	11.7
Yes, because they have a plan	17	22.1
Yes, because they have all the equipment that will be needed	1	1.3
Yes, because the posters up show exactly what to do	7	9.1
Yes, because of the warning system in place	11	14.3
Yes, because most buildings are out of lahar paths	1	1.3
Yes, because they should be prepared and have to be	4	5.2
No, because you can't hear the speakers on some parts of the mountain	1	1.3
No, because there is no way to know how the lahar will act	2	2.6
No, because staff should get more training	4	5.2
No, because staff don't to know the chain of command	1	1.3
No, because staff don't know evacuation procedures	3	3.9
No, because it is difficult to evacuate a large number of people as there is only one road out	2	2.6
No, because they need to have a simulation or some form of practical training	2	2.6
No, because staff and public do not have enough knowledge	3	3.9
Don't know, because I haven't seen them in practice	2	2.6
Don't know, because they may not know what they're doing	1	1.3
Don't know, because a lahar is different than any other hazard	1	1.3

**Table 13: Were your role requirements during a lahar warning (i.e. actions you will be expected to take) explained clearly?**

	Responses	
	Count (n=89)	Percent (%)
Yes	48	53.9
No	23	25.8
Sort of	3	3.4
No response	15	16.9

**Table 14: What are your role requirements during a lahar warning?**

	Responses	
	Count (n=89)	Percent (%)
Move people away from lahar paths	2	2.6
Move group to safe area	42	54.5
Stay in safe area	4	5.2
Remove skis and snowboards	1	1.3
Walk/climb up onto ridges	1	1.3
Put your own safety first	2	2.6
Move people to higher ground	13	16.9
Move people into buildings	1	1.3
Calm people	18	23.4
Give out information	13	16.9
Don't panic	1	1.3
Get all customers down the mountain safely	4	5.2
Move people out of valleys	1	1.3
Take instructions from a supervisor	7	9.1
Never explained	6	7.8
Get inside a building	5	6.5
Get customers off lifts	4	5.2
Call last number, shut lift down	1	1.3
Evacuate building	1	1.3

**Table 15: Does it involve working with others?**

	Responses	
	Count (n=89)	Percent (%)
Yes	76	85.4
No	6	6.7
No response	7	7.9

**Table 16: Do you feel your training for working with others was adequate?**

	Responses	
	Count (n=89)	Percent (%)
Yes, we had safety training already	9	18.0
Yes, I already work with people in my job	16	32.0
Yes, I know how to work with people	8	16.0
No, the training was not specific enough	4	8.0
No, we need to do simulation/scenarios	5	10.0
No, I have not had any training for working with others in case of an emergency	13	26.0
No, I feel staff assigned to certain areas should have a meeting to discuss what will happen	1	2.0

**Table 17: What sorts of situations do you think could be most stressful when the lahar warning system activates?**

	Responses	
	Count (n=89)	Percent (%)
Panicking customers	50	58.8
Lost children/missing people	14	16.5
Non-English speaking people	5	5.9
Ignore warning signal/sirens	3	3.5
Keeping customers calm	4	4.7
Keeping customers organized	1	1.2
Keeping customers in buildings	1	1.2
People failing to listen	10	11.8
Safety of people on the mountain	3	3.5
Confusion	8	9.4
Public reaction	9	10.6
Being stuck in valleys on the mountain	5	5.9
Customers not knowing where to go	12	14.1
Not knowing where to get information	2	2.4
Skiers getting injured	2	2.4
High number of customers on the mountain	6	7.1
Bad weather	3	3.5
Moving people out of valleys	2	2.4
Traffic on the road out	2	2.4
People being pushed over in crowds	5	5.9
People worried about gear	1	1.2
Rescuing those who are not near a safe zone	1	1.2
People going into unsafe areas	1	1.2
Lone skiers	1	1.2
Prioritizing	1	1.2
Helping disabled people	1	1.2
Beginner skiers having a hard time moving to safe areas	1	1.2
Lahars following a new route, possibly into a safe zone	1	1.2

**Table 18: What are the different possible reactions from customers to a lahar warning?**

	Responses	
	Count (n=89)	Percent (%)
Panic	73	83.9
Confusion	22	25.3
Shock	6	6.9
Do something stupid, reckless, dangerous	3	3.4
Nervous/anxious behaviour	12	13.8
Stressed out	13	14.9
Unreasonable behaviour	5	5.7
Don't listen	7	8.0
Ignorance	6	6.9
Think it's a drill	2	2.3
Fear	18	20.7
Anger	5	5.7
Wanting to leave	3	3.4
No reaction	1	1.1
Ask a staff member what to do, what is going on	4	4.6
Calm	6	6.9
Cooperation	3	3.4
Obedience	3	3.4
Excitement	2	2.3
Interest/Curiosity	7	8.0

**Table 19: What kinds of customer needs do you think you might have to deal with?**

	Responses	
	Count (n=89)	Percent (%)
Injuries	14	17.9
Stress	10	12.8
Location of family members	20	25.6
Reassurance/patience	24	30.8
Letting them know what is happening	22	28.2
Dealing with fear	7	9.0
Non-English speaking customers	5	6.4
Irrational concerns	1	1.3
Dealing with children	1	1.3
Supplying food/water/shelter	3	3.8
Helping disabled people/people that need assistance to move	7	9.0
Safety	9	11.5
Helping them to evacuate	5	6.4
Every kind	1	1.3

**Table 20: Do you think you received adequate training to deal with these issues?**

	Responses	
	Count (n=89)	Percent (%)
Yes	40	44.9
No	45	50.6
Sort of	2	2.2
No response	2	2.2

**Table 21: Do you think you have received adequate training to deal with these issues?**

	Responses	
	Count (n=89)	Percent (%)
Yes, because I feel confident I will be able to keep customers calm	2	3.1
Yes, because it is common sense	11	17.2
Yes, because the training already received was good	13	20.3
Yes, because we received awareness of safe zones	5	7.8
No, because it was not specific enough	4	6.3
No, because I haven't had experience with a situation like this before	5	7.8
No, because I didn't receive any lahar hazard training	22	34.4
No, because we should have on-hill training/simulation	5	7.8
No, because there was no training on dealing with injured people	4	6.3
No, because we weren't give any information to keep to look over	1	1.6
Won't know until it happens, can't really train for it	4	6.3



**Table 21: What are the potential consequences to skiers in the path of a lahar when it enters the ski area?**

	Responses	
	Count (n=89)	Percent (%)
Injury	33	40.7
Death	60	74.1
Getting trapped/isolated	7	8.6
Take out lifts/buildings that customers may be on/in	4	4.9
Getting caught up in the lahar	24	29.6
Getting caught in an avalanche caused by the lahar	1	1.2

**Table 22: Have you seen any public education on volcanic hazards at your ski field?**

	Responses	
	Count (n=89)	Percent (%)
Yes	70	78.7
No	18	20.2
No response	1	1.1

**Table 23: What do the posters on volcanic hazards say?**

	Responses	
	Count (n=89)	Percent (%)
Don't know	1	1.5
Listen to sirens	3	4.6
Evacuate to car parks	1	1.5
Information about lahars	4	6.2
Shows possible lahar paths	22	33.8
Shows safe areas	34	52.3
Risks	1	1.5
Procedure to follow	28	43.1
Volcanic Hazards	15	23.1
Warning system	11	16.9
Previous Damage	2	3.1
Move out of valleys to higher ground	5	7.7
General information	3	4.6

## **APPENDIX 4: SIMULATION OBSERVATIONS**

Simulation – August 3<sup>rd</sup>, 2005

### Happy Valley

- Great response
- A good response by most staff because they knew about the test
- Staff got people off chairlift, then stopped it. Didn't load anyone. Gave instructions to some people
- Snow School Instructors stopped people from skiing, got them to move back to top

### Top of the Bruce

- Staff reacted in a calm manner
- Staff relaxed and calm looking to see if public are moving
- Staff stopped cars, said it was a lahar warning
- Took a couple of minutes before staff stopped chairlifts

### Hutt Flat

- Centennial offloading staff moved people to a ridge above the chairlifts, told to remain still up on ridge area
- Staff gave information on what was happening
- Staff at chairlifts were telling people where to go
- Staff member was telling people not to ski down
- Lifts stopped awhile after alarm

### Rockgarden

- Staff at drive station could not hear the alarm

### Waterfall Express Chair

- Staff at loading area stopped people going any higher, gathered people outside loading area
- One staff member did a sweep under the chair
- Chair sped up and emptied
- Lift was sped up
- Staff didn't react, didn't give any instructions at bottom of the Waterfall chair

### Knoll Ridge Café – Outside

- One staff member walking around, but not giving any directions
- Lots of staff standing around doing nothing
- No instructions given
- Asked someone on staff if they were in the right place, and staff member said yes
- Didn't hear or see any café or retail staff
- One staff member seemed more concerned about what was happening at the Valley T-Bar

### Knoll Ridge Café – Inside

- Café staff continued to clear tables saying nothing.
- Staff didn't give any instructions
- Staff didn't do anything

### Knoll Ridge T-Bar

- At loading area, took staff a long time to convince punters to move
- At offload area, a ski patroller came through giving directions
- T-Bar stopped as soon as alarm sounded

- Liftie said to move to higher ground, stopped lift
- Liftie stopped lift, no other action

#### Waterfall T-Bar Area

- At drive station, lift was stopped 60 seconds after the alarm, the lift queue was moved
- A Ski Patroller had to tell the liftie to stop the lift
- Trail Safety staff boarded right thought about 2 minutes after the siren through lahar path, to move public who were already in a safe spot. As a result, skiers moved through lahar path.
- After all clear, liftie still waited for supervisor to give all clear
- No staff at offload area to begin with, but two staff members eventually came into view, could hear them yelling for people to move
- Trail Safety member went down run doing a sweep
- Took liftie awhile to shut down the T-Bar
- A Ski Patrol member said it was a drill, but to get up the side
- At loading area, staff asked people to remove gear and move to a safe point
- T-Bar didn't stop immediately
- At loading area, staff member turned off his stereo so he could hear the alarm, told everyone to get up the hill and leave their gear. As soon as he heard the alarm, he shut off lift

#### Valley T-Bar

- Valley Drive Station – received call from RAL after lift stopped
- Liftie unsure what was happening, couldn't hear alarm, told everyone to move to higher ground, gave reason way
- Staff called to people on lift to move to high ground, staff member was last to leave lift area
- Lift immediately stopped
- Liftie at loading area directed people to Knoll Ridge Café
- No staff reaction
- Saw a staff member doing a sweep down the run
- T-Bar was stopped quickly

#### Far West area – Top

- Groomers were only staff within the area, no response but likely unnecessary as they were in a safe area

## **APPENDIX 5: BLIND TEST OBSERVATIONS**

Blind Test Observations of Staff – October 12<sup>th</sup>, 2005

### Top of the Bruce

- A few staff around, some went to the lifts but didn't address the public
- Outside rental area, staff gave clear instructions
- Asked staff inside LBC what was happening, the staff explained what a lahar was and told them to stay as the TOB is a safe zone
- Two staff were present, told people at the table what was happening (warning, lahars, etc), said this is a safe zone
- Inside Rentals area, staff kept serving customers
- Rental staff told customers they are just doing another test
- Most staff stayed where they were. Trail Safety staff and Customer Service manager were outside in the plaza explaining to people to stay where they were
- Road Services staff told her to stay put, and stopped cars at the loop

### Hutt Flat

- Snow School Instructors had delayed reactions, but were eventually efficient at moving groups up the ridge and could hear several answering customers questions
- Staff offloading the Centennial chair kept offloading, but didn't tell customers anything
- Waterfall Express lifties could not be seen, but heard chairlift speed up instantly
- Staff were good and did the right thing
- Staff talked to the public to let them know it was a test

### Rockgarden

- Staff knew what to do

### Waterfall Express Chair

- Lift initially stopped then started again moving faster
- Only one lift operator was present at off-loading area, not enough to assist skiers as many were falling trying to get off lifts in a hurry. Customers told to move towards Knoll Ridge Café
- Chair was speed up, then staff directed everyone to café
- Chair speed up, reached top quickly, directed to Knoll Ridge café
- At Drive Station, staff went to phone to confirm and held everyone back, stopped loading
- Staff member was skiing down and didn't say anything

### Knoll Ridge Café – Outside

- Ski School told customers to stay
- Staff were good, helped children who were alarmed by siren
- No reaction from staff
- RAL informed people it was a test

### Knoll Ridge Café – Inside

- Staff instructed public to stay where you are
- Staff had a hard time hearing alarm inside the building
- No staff did anything
- No response from staff
- No staff in Knoll Ridge café appeared to hear the warning
- No staff reaction
- No staff reaction
- No staff reaction, likely didn't hear alarm
- No response

Knoll Ridge T-Bar

- Staff good, moved people to higher ground, acted like alarm was real
- There was a skidoo with one person who was checking the speakers, customer asked what was happening and were told it was a drill
- Staff member told customers to get to higher ground
- Liftie at bottom of T-Bar directed public towards Knoll Ridge café and stopped the T-Bar
- T-Bar stopped
- Ski Patrol carried on
- Didn't load anyone once alarm went off, then ran the lift so last 4 T's could get up back to Knoll Ridge Café
- Staff member tried to alert and explain to public what was happening, but the alarm was too loud

Waterfall T-Bar Area

- Staff had a good response, well organized
- Ski Patrol were very quick and gave clear precise instructions
- Liftie did really good job instructing public
- Ski Patroller told people to go to higher ground, staff gave good instructions
- At drive station, staff acted appropriately telling people to move to higher ground
- At offload, a staff member was telling people to go to the Knoll Ridge café
- Went 1/3 of the way up the T-Bar before it stopped
- At drive station, liftie took 30 sec. to react, likely because he couldn't initially hear alarm
- Ski Patroller arrived at area 4 minutes after siren after completing a sweep

Valley T-Bar

- Ski Instructor gave clear instructions to his clients and they moved directly off area
- T-Bar stopped immediately, staff turned off lift immediately
- Staff near drive station told people to move down valley and wait on ridge
- Ski Patrol came down the run asking people to move out of the valley
- Ski Patroller pointed everyone to higher ground, told them to follow him
- T-Bar stopped a little bit after alarm sounded

Far West area - Top

- two staff at top of T-Bar told people it was a lahar warning and to ski to the café and wait there. The one staff member at the café was unsure of what to do
- Ski Patrol staff member was seen on a skidoo going down the run
- Ski Patroller directing people back east

Far West area – Bottom

- Staff stopped lift, instructed customers to get out of valleys
- one customer went the wrong way, lift operator called him back to the lift area
- Very good response, although nobody was around as the lift was closed at the time
- Liftie staff in loading area reacted well, telling people to get to higher ground
- staff sped up chair and acted in calm manner telling everyone to go to café in clear loud voices
- Many customers queried staff as to whether it was a test or not

Communication Comments

- Was listening to Ski Patrol radio and about 5 minutes before alarm, a patroller said 'so should we assign sweep positions for the warning', and another Ski Patrol member said 'ok' and began assigning positions. This kind of defeats the purpose of a blind test
- However, after this, Ski Patrol seemed to have a good response at carrying out sweeps, with the head Ski Patroller reassuring Ski Patrollers that they were responding to a 'real' alarm, explained what patrol should do, and organized sweeps

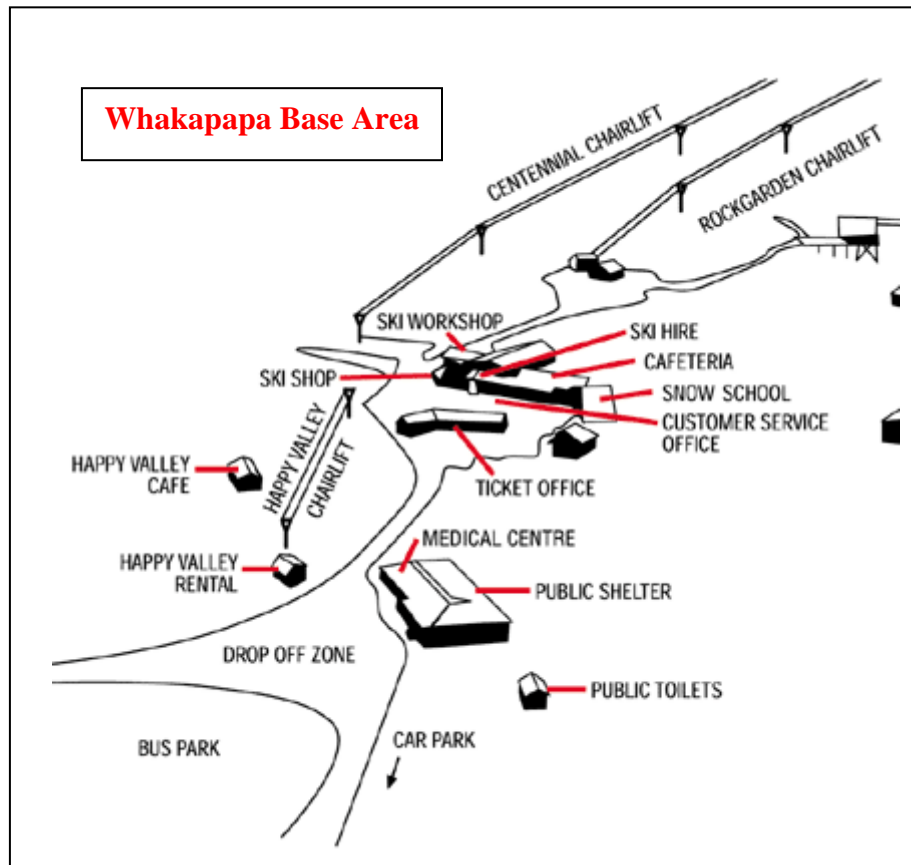
## APPENDIX 6: INTERVIEW CODES

These themes and sub-categories (sub-themes) were used to pull similar ideas from the interview data. The number in brackets behind each sub-category indicates how many times this sub-category was mentioned in total in all the interviews combined.

1. Daily jobs
  - a. Training (67)
  - b. Tasks (78)
  - c. Customer service (10)
  - d. Daily hazards (38)
2. Lahar training
  - a. RAL training (141)
  - b. Common sense (10)
  - c. Forget (11)
  - d. Never attended (12)
  - e. CIMS (18)
3. Awareness/Knowledge
  - a. Personal experience (58)
  - b. Reliance on second hand/expert knowledge (50)
  - c. Public education (85)
  - d. Over-educated (1)
  - e. Inexperience (19)
4. Past events
  - a. Knowledge of 1995/96 eruptions (64)
  - b. Past damage (25)
  - c. People's reaction (10)
  - d. Experience (22)
5. Eruption event
  - a. Unpredictability (21)
  - b. Interest/curiosity (15)
  - c. Uniqueness (4)
  - d. Acceptance (23)
  - e. No control (20)
  - f. Different style eruption (30)
  - g. Hazards (61)
  - h. Warning time (22)
  - i. Uncertainty (65)
  - j. Crater Rim failure (17)
6. Lahars
  - a. Uncertainty (28)
  - b. Effect (20)
  - c. Knowledge (65)
7. Warning system
  - a. Knowledge (39)
  - b. Concern (10)
  - c. Uncertainty (28)
8. Tests
  - a. False alarm (22)
  - b. Blind test (21)
  - c. Simulation (39)
  - d. Loss of urgency (30)
  - e. Importance (12)

9. Procedure/response to eruption
  - a. Knowledge of actions (212)
  - b. Plan (39)
  - c. Efficiency (30)
  - d. Safety (42)
  - e. Concern (62)
10. Evacuation
  - a. Uncertainty (61)
  - b. Concerns (26)
  - c. Efficiency (24)
  - d. Procedure (51)
11. Responsibility
  - a. Staff (12)
  - b. Managers/supervisors (48)
  - c. Public (0)
  - d. DoC (24)
  - e. Safety Services (49)
12. Communication
  - a. Method (111)
  - b. Instructions/Information (130)
13. Stressors
  - a. Job loss (23)
  - b. Closure (40)
  - c. Damage (lifts, buildings) (43)
  - d. Public reaction (74)
  - e. People scared away (11)
  - f. Road problems (19)
  - g. Finding people (23)
  - h. High number of customers on ski area (34)
  - i. People isolated by lahar (15)
  - j. Waiting for instructions (4)
  - k. Out-of-bounds skiers (6)
14. Consequences
  - a. Death (42)
  - b. Injury (17)
15. Coping
  - a. Individual (14)
  - b. Debriefing (13)
  - c. Counselling (30)

## APPENDIX 7: WHAKAPAPA AND TUROA SKI AREA MAPS AND BASE AREA LAYOUTS







**Whakapapa Trail Map**

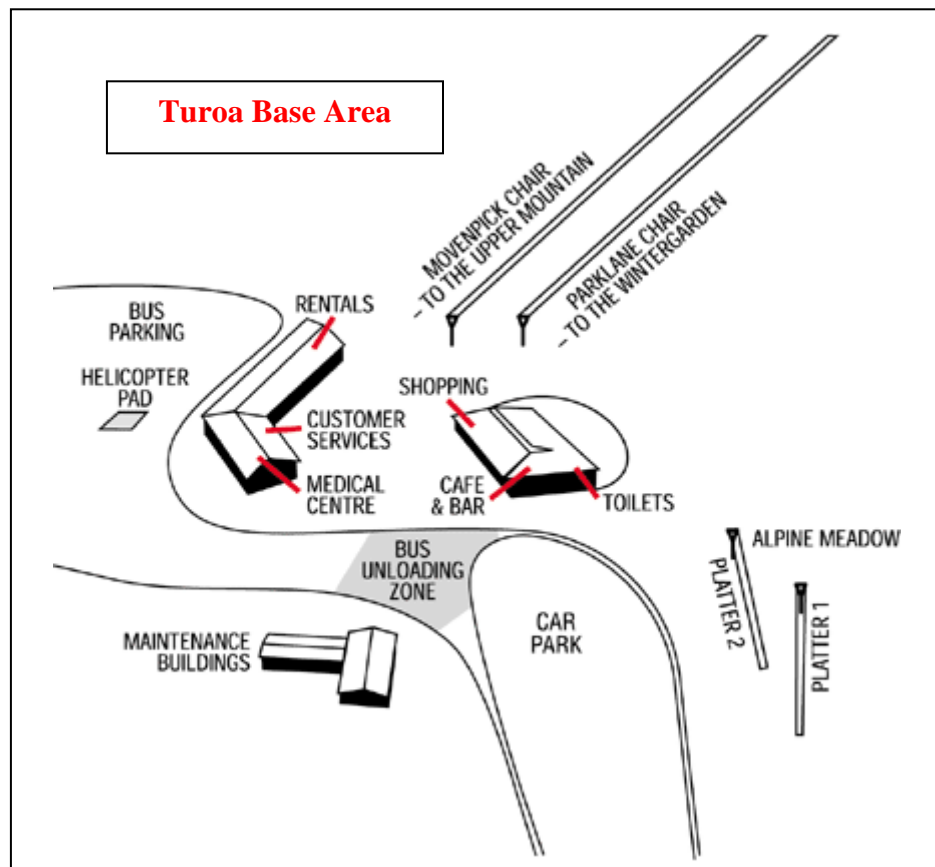
## TRAILS

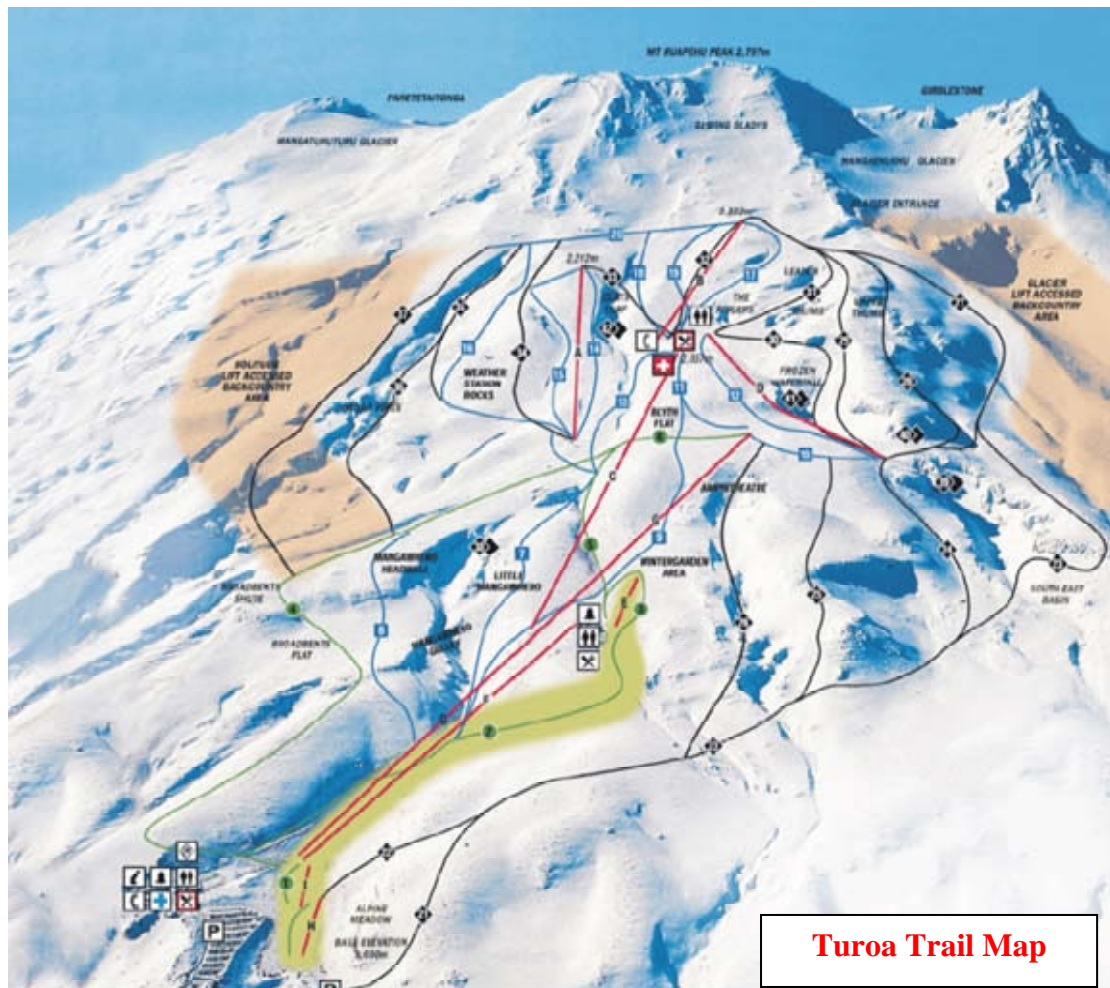
- |                              |                                 |
|------------------------------|---------------------------------|
| 1 Happy Valley Beginner Area | 22 Cornice Bowl                 |
| 2 Hut Flat Beginner Area     | 23 Delta Trail                  |
| 3 Christies                  | 24 Traverse of Fear             |
| 4 Rockgarden                 | 25 The Gut                      |
| 5 Tennant's Valley           | 26 Knoll Face                   |
| 6 Tennant's Ridge            | 27 Cut Back                     |
| 7 Home Run                   | 28 Turtle Run                   |
| 8 Murphie's Schuss           | 29 Shirt Front                  |
| 9 Downhill Easy              | 30 Valley Traverse              |
| 10 Goomie Bowl               | 31 Valley Highway               |
| 11 T1                        | 32 Bilbo's                      |
| 12 Riviera Paradise          | 33 Gollum                       |
| 13 Venom                     | 34 Pinnacle Valley              |
| 14 Milk Run                  | 35 K Road                       |
| 15 Turner's Gully            | 36 Valley Exit                  |
| 16 Dreamer                   | 37 The Tarraces                 |
| 17 Turn Pipe                 | 38 Nose Dive                    |
| 18 Three Pin Ridge           | 39 The Staircase (skiers right) |
| 19 Twin Rocks                | 40 The Staircase (skiers left)  |
| 20 Twin Rocks                | 41 Honeymoon Valley             |
| 21 S Bends                   |                                 |

- ◆◆ 42 Pinnacles Traverse
- ◆◆ 43 Front Stage
- ◆◆ 44 Back Stage
- ◆◆ 45 Grand Gully
- 46 Broken Leg Gully
- 47 Couloirs
- 48 The Waterfalla
- 49 High Traverse
- 50 McKenzie's Mistake
- 51 The Chimmney
- 52 Yankee Face (exit to Hut Flat)
- 53 Yankee Face
- 54 Steve's Bowl
- 55 Aeroplane Gully
- 56 Yankee Slalom
- 57 Amphitheatre
- 58 Wizards
- 59 Black Magic
- 60 Stebbings
- 61 Screamer
- 62 Heensli Face

## LIFTS

- A Far West T Bar
- B West Ridge Chair
- C National Chair
- D Happy Valley Chair
- E Double Happy Chair
- F Happy Valley Platter 1
- G Happy Valley Platter 2
- H Rockgarden Chair
- I Hut Flat Rope Tow
- J Centennial Chair
- K Waterfall Express Chair
- L Waterfall T Bar
- M Knoll Ridge T Bar
- N Valley T Bar





### TRAILS

- 1 Alpine Meadow Beginner Area
- 2 Clarry's Track
- 3 Wintergardes Beginner Area
- 4 Home Run
- 5 Boneyard
- 6 Blyth Flui
- 7 Bypass Trails
- 8 Show Off
- 9 Lower Freeway
- 10 The Terrace
- 11 Upper Freeway

- 12 Yahoo
- 13 Wilynx
- 14 Broad Run
- 15 Main Trunk
- 16 Branch Line
- 17 Vertigo
- 18 Big Bowl
- 19 Little Bowl
- 20 High Traverse
- 21 4th Sister
- 22 1st Sister

- 23 Once Only
- 24 Cloch
- 25 Blackburn
- 26 Amphitheatre
- 27 Triangle
- 28 Muzzzone
- 29 Hamilton's Face
- 30 Clarkes Mistake
- 31 Blackhand
- 32 Snowbird
- 33 Elevator Shaft

- 34 Raceline
- 35 Slider
- 36 Organ Pipes
- 37 Layback
- 38 Mangawhero Chutes
- 39 Mungatetei Cirque
- 40 Tardis Chutes
- 41 Black and White Chute
- 42 Clay's Chutes

### LIFTS

- A Jumbo T Bar
- B High Noon T Bar
- C Giant Chair
- D Hightyer Chair
- E Wintergardes Platter 1
- F Parklane Chair
- G Movenpick Chair
- H Alpine Meadow Platter 1
- I Alpine Meadow Platter 2